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OF

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VOLUME IV.

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that the physical exertion and fatigue corresponding to this, is being employed in destroying the lathe.

It is very advisable also that the rotating parts of a lathe should be accurately balanced, and this is especially the case with light lathes, which are driven at a high velocity. The driving-wheel is sometimes purposely made heavier on one side so as to overbalance the weight of the treadle and connecting gear, and prevent the crank stopping on the centres. In this case a greater evil is obviated than is introduced, as the driving-wheel does not run at a very great velocity. But the driving-arm of the dog-plate, or the connecting bolt for the double gearing, when unbalanced, will in fast-running lathes cause considerable vibration of the whole lathe, and render the production of good work a matter of impossibility.

Fig. 27 (Vol. III., p. 313) shows the kind of hand-lathe chiefly employed by engineers, and these are driven from overhead in the manner already explained. Sometimes, where many are used, they are mounted several upon one long iron bed, instead of on separate beds as in the figure. The counter-shafting is also placed in a line overhead, and the belt-shifting levers are generally brought down and connected with a long horizontal rod placed in front of the lathe-bed, so as to be within reach of the workman, wherever he may be standing at his work. In the early days of mechanical engineering all the work had to be turned in hand-lathes, and turning was often a very tiresome and laborious occupation. But now the hand-lathe is reduced to a very subordinate position in the workshop, being chiefly employed in preparing work for self-acting lathes, and in completing the shape of such odd and inaccessible corners as the self-acting lathes cannot so conveniently operate upon. The old school of millwright hand-turners is now very nearly extinct, but I have heard members of it say that those who attend to self-acting lathes are not turners at all, and even maintain that the work they produced in their youths was equal both in quality and quantity to that produced by the aid of the self-acting lathe. Neither of these statements will bear much investigation, but I have worked with and known hand-turners, not only in wood but in metals, who could run a self-acting turner a very close race in certain classes of light turning which are now almost exclusively executed in self-acting lathes.

The hand-lathe is adapted to plain turning in any material. The materials chiefly used are woods of various kinds, iron and brass, and not only does each of these substances require different tools and different treatment, but each material varies so much in texture and density as to require corresponding variation in the means employed in working it. Wood, for instance, may be obtained of very different densities. Some of it is readily indented, and may almost be cut by the finger-nail; other varieties are almost as hard and quite as difficult to turn as some of the metals. The tools suitable for cutting the softer varieties of woods would be greatly damaged if used upon some of the hard woods, and if the hard-wood turning tools were employed upon soft woods the result would be equally unsatisfactory, although in this case the tools would have the best of the encounter. Iron, again, if of good quality, is comparatively soft, and some varieties are so soft that they may be acted upon by tools which would produce a fair result even upon soft woods. Other sorts of iron are much less tractable, and cast iron requires quite different treatment to that suitable for soft wrought iron. Steel, if well annealed, is as soft and as easily turned as good wrought iron. If improperly annealed it may require much the same tools and treatment as cast iron, or it may be so intractable as to be a most difficult and unsatisfactory substance to deal with. Hardened steel, or steel that has been made red hot and suddenly cooled by immersion in cold water, is quite invulnerable so far as cutting is concerned, although it may be shaped by other means.

Brass also exhibits very similar properties. As a rule it may be turned in much the same way as good cast iron; but whereas soft brass may be ripped off with ease and rapidity, hard brass is very nearly as intractable as hardened or partially hardened steel. Ivory and some other materials of similar texture chiefly used for ornamental work are operated upon by tools of much the same character as some of the hard woods.

Copper, lead, and zinc are not much employed for turned articles. They are easily turned with the tools suitable for wrought iron, and require no very distinctive treatment.

The softer fibrous woods require very keen tools, with a cutting edge formed with a very acute angle. For the denser woods the angle must be much more obtuse, although the cutting edge should still be kept keen and well sharpened. As a general rule, the softer the material the more acute should be the angle of the cutting tool.

Then again, not only must the cutting tool be adapted to the nature of the material it is required to operate upon, but the speed of cutting must be similarly varied. The soft wood may be driven at a very high velocity whilst being turned, and within certain limits the faster the speed the smoother and more satisfactory does the tool cut. For iron and well-annealed steel the speed must be considerably reduced. The surface to be cut should not pass the tool's point at a much greater velocity than eighteen feet in a minute. Cast iron is usually driven somewhat slower than this, and brass and lead rather faster. The harder the material the slower must it be driven past the cutting tool. The operator soon gets to know how fast he can advantageously drive his work, as if the speed be too great his tools rapidly lose their cutting edge, and if the excessive speed be continued the temper of the tool is injured, owing to the great heat developed by the friction caused by the tool's rubbing against the work instead of cutting it. An experienced turner can tell at a glance whether the speed is correct for the material he wishes to cut, but the beginner requires to exercise a good deal of care if he wishes to keep his tools in proper order.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIII.—NICHOLAS COPERNICUS.

BY JAMES GRANT.

In Vol. II. of The Technical Educator it has been shown how Galileo, in the sixteenth century, was the first who taught physics to speak the language of truth and reason; but it was a little before his time that Nicholas Copernicus discovered the true system of the world, and invented that method of astronomy which still bears his name.

He was born on the 10th of January, 1472, in the quaint old town of Thorn (in Polish Prussia), which twenty years before had revolted against the tyranny of the Teutonic knights, and been incorporated with the kingdom of Poland. He was taught Latin and Greek at home, but afterwards was sent to Cracow, to study philosophy and physic at that famous old university which had been began by Casimir the Great, and finished by Udislaus Jagello. In his twenty-third year he set out for Italy. His genius had now turned to mathematics, which he studied in all its various branches; thus he stayed for a time in Bohemia for the sake of being with the celebrated astronomer, Dominicus Maria, whose society he cultivated, less as a learner, than as an assistant to him in making his observations. From Bohemia he proceeded to Rome, where he speedily won a reputation that was considered no way inferior to that of the famous Regiomontanus; and his name became so famous, that he was chosen professor of mathematics, which he taught for a long time with great applause, during the stormy period when Pope Alexander VI. occupied the chair of St. Peter.

In the year 1500 he made some important astronomical observations at Rome, and on returning to his own country he began to apply his vast knowledge in mathematics to correct the system of astronomy which then prevailed. He set himself to collect all the books which had been written by philosophers and astronomers—no easy objects of acquisition in the first years of the sixteenth century—and to examine all the various hypotheses they had invented for the solution of the celestial phenomena, seeking thereby if a more symmetrical order and constitution of the parts of the world could not be discovered. Of all the hypotheses of the ancients, none pleased him so well as the Pythagorean, which made the sun the centre of the system, with the earth and planets revolving round him in their own orbits.

Many of the ancients, he found, had maintained this idea; particularly Ecphantus, Seleucus, Aristarchus, Philolaus, Cleonthes Samius, Nicetas, Heraclides Ponticus, Plato, and, lastly, Pythagoras. Archimedes also, in his book of the number of the grains of sand, had maintained the Pythagorean system, but until the days of Nicholas Copernicus it was dropped and forgotten. After long and profound contemplation, and after

many calculations, the learned Pole removed some of the obscurities of the old system and improved it. These discoveries and improvements he embodied in a work on astronomy, the publication of which, knowing the perils that then surrounded those who dared to broach new opinions, he with great prudence suppressed, until he found a powerful lover of astronomy to protect him in the person of Pope Paul III., a learned, bountiful, and magnificent prelate—the same who boldly cited Henry VIII. of England to appear before the College of Cardinals, there "to answer for his adultery and other crimes."

In this system none of the celestial bodies shine with their own native light, save the sun; so that all the planets, both primary and secondary, are opaque bodies, that have no other light but that which they receive from the sun, and reflect back towards the earth and other planets. This is most evident from the moon; for only that side of her is observed to shine, which is directly opposed to the sun; while the other side which is turned from the sun is quite dark, except so far as it is illuminated by reflection from the earth. We see her, indeed, more or less illuminated in proportion as more or less of the surface on which the light of the sun is shed is turned towards the earth, as is evident on watching her through her various phases. Thus at the full she appears all illuminated, and at the change all dark. The same phenomena are observable in Venus and Mercury, which show all the phases of the moon, and sometimes appear like a black spot upon the luminous body of the sun. Mars likewise appears gibbous when near the quadratures of the sun. The satellites of Jupiter are eclipsed when they are behind his body, being then lost in his shadow; they likewise cast their shadows on the body of Jupiter. In Saturn the shadow of the ring upon his body proves his opacity; while the weakness of the light of those planets which are remote from the sun shows that it is not innate, but borrowed.

All the planetary bodies, Copernicus maintained, were nearly spherical, and that all of them had a rotation round their axis. These motions are found by means of certain spots upon their surfaces, which fix the time of their rotation. In some planets, from the absence of such indications, the times of their revolution have not yet been found. That they are spherical bodies appears from the slow motion of the spots near their edges, and their swifter motion near the middle. Likewise the line separating the illuminated part from the dark is always elliptical, which proves their form to be spherical.

Such was the system of Copernicus, who so fully revived that of Pythagoras, and thus inaugurated a new and important epoch in the history of astronomy, which we may justly reckon the most ancient science in the world, for Josephus tells us that Seth erected two pillars, one of stone and the other brick, whereon were graven the principles of that science.

In the dedication of his labours to Pope Paul III., Copernicus tells his holiness, that "he had suffered the fruit of his labours to ripen, not nine years only, but four times nine."

At length he committed the care of the impression to two friends named Schoner and Osiander in a distant city, where the work was printed in 1543, under the title of "De Revolutionibus Orbium Cœlestium," and the author, then residing at Frauenburg, a little town on the shores of the Haff, not far from Kœnigsberg, received a copy of it but a few hours before his death, which occurred on the 24th of May in the same year.

He resided in a house near the cathedral (of which he was a canon), and in the latter, a handsome building on a height overlooking the town and the Haff, he was buried; and there are still preserved, besides his tomb—a simple tablet bearing a globe—some curiosities and relics, such as crucifixes, and other things which belonged to him.

Within the enclosure of the cathedral is a well furnished with water by an aqueduct and hydraulic pumps constructed by him. The machinery of these pumps has, of course, long since disappeared; but a model of it is still preserved in the cathedral, and is supposed to have been imitated in the water-works at Marly. The tower which contained it stands near the cathedral, and is called the *Kunst Thurm*.

Besides supplying the Domberg (or cathedral hill) with water, he introduced it into the town of Frauenburg, by collecting from the neighbouring streams a current of water sufficient to turn a corn-mill, an advantage which its inhabitants did not previously enjoy. On the southern wall of the *Kunst Thurm* there is still traceable the following inscription to the memory of Copernicus:—

"Hic patienter aquæ sursum properare coactæ,
Ne careat sitiens incola montis ope.
Quod Natura negat, tribuit Copernicus arte;
Unum pro cunctis fama loquatur opus."

Few works that the world has seen have destroyed more riveted and deeply-rooted errors, or have established more important truths, than the great book of Copernicus. His noble theory, now so well known as the Copernican system, was at first coldly received, or utterly rejected; but the labours of future astronomers at length obtained for it complete triumph. Copernicus was also the first who demonstrated the double orbit of the moon—her menstrual motion about the earth, and her annual about the sun. Nor did this great man stop here; for after laying a solid foundation of the celestial physics, he began the superstructure, by surmising a principle of attraction to be inherent in all matter.

Copernicus also wrote a tract on trigonometry, and has also, as we have shown at Frauenburg, exhibited tokens of the versatility of his talents. He was very familiar with the Greek and Latin languages, and was acknowledged to have considerable skill as a painter.

In 1616, when Paul V. occupied the pontifical chair, seven inquisitors passed a decree at Rome, declaring that the opinions of Copernicus, as demonstrated by Galileo, were *not only heretical in faith, but absurd in philosophy*. "This sentence," says Voltaire, "against an opinion which has since been so variously confirmed, is a pregnant testimony of the force of prejudice. It should be a lesson to those who have nothing but power on their side, to be silent when philosophy speaks, and not to attempt to determine points which do not fall under their jurisdiction."

Galileo, as we have shown in his memoir, was condemned by the same severe tribunal to do penance in prison, and to retract on his bended knees! And it is a curious fact, and perhaps not generally known, that the Papal excommunication of Copernicus for publishing his "System of the Revolution of the Heavenly Bodies" was not revoked until 1821!

His name is still borne by an astronomical instrument invented by Whiston, to show the motion and phenomena of the planets, both primary and secondary. It is founded upon the Copernican system, and therefore is called by his name.

FARMING AND FARMING ECONOMY.—XV

By Professor Wrightson, Royal Agricultural College, Cirencester.

BREEDS OF CATTLE (*continued*).

HEREFORDS—DEVONS—SUSSEX—LONG-HORNS—NORFOLK AND SUFFOLK—WELSH BREEDS—GALLOWAYS—ANGUS OR ABERDEEN—WEST HIGHLANDERS—AYRSHIRES—IRISH CATTLE.

To give a minute and graphic description of an animal is by no means easy, and in the remarks which follow we shall endeavour to give only a general idea as to the appearance, character, distribution, and history of the remaining races of British cattle.

Hereford Cattle are principally found in the south-west of England, and, according to the late Mr. H. H. Dixon, few counties south of Shropshire are without them. They are to be seen grazing on the rich marshes of the eastern counties, and have pushed their way into Surrey on the south-east, and Cornwall on the south-west. They are seldom seen in the north of England, and we only know of two herds in Scotand. They have met with supporters in Ireland, and a considerable export trade exists in breeding animals to Jamaica, Canada, the United States of America, and Australia. Although four varieties of Hereford cattle are described—the red with white faces, the red with mottled faces, the light greys, and the dark greys—the first is the most ordinary type. They are all large and imposing in appearance, and are of a fine red colour, broken with white upon the breast, face, mane, ridge of back, end of tail, and occasionally on the feet. Their fattening propensity at mature age is quite equal to that of Short-horns. Doubt has, however, often been thrown upon their flesh-producing powers at from two to three years old. That this is founded on fact is, however, open to doubt. But in order to throw light upon an important question, we abstract the following table from the *Agricultural Gazette* of December 17th, 1870,

where not only the average weight and ages of Short-horns and Herefords are given as obtained at the Islington show of that year, but also the average weights of Devon and Sussex cattle. The result obtained by the scales was as follows for oxen:—

Oxen.	No. of Class.	Average Age.		Average Live Weight.		
		yrs.	mths.	cwt.	qrs.	lbs.
Devons	7	2	4	10	0	20
Herefords ...	6	2	4½	14	1	13
Short-horns ...	4	2	4	15	3	0
Devons	8	3	2	13	2	22
Herefords ...	4	3	0	15	3	1
Short-horns ...	5	2	11¾	17	0	18
Sussex	4	2	9	15	0	6
Devons	8	4	1½	16	0	26
Herefords ...	13	4	0½	19	2	23
Short-horns ...	9	3	10½	18	3	10
Sussex	7	3	10½	19	0	12

Lord Scudamore, who died in 1671, is recorded as having introduced red cows with white faces from Flanders, and from these, the calf in question, as well as others—for we can hardly give credit to the assertion that all the "white faces" are descendants of one bull—may have derived their colours. The Herefords, like the Short-horns, have a history. Their improvement was due to the labours of the Messrs. Tomkins, Weyman, Yeoman, Tully, and Hewer, from about the year 1766. Since then the breed has been carefully kept up, and the pedigrees of pure-bred animals have been preserved in a Herd Book commenced in 1845 by Mr. Eyton, and continued since 1857 by Mr. Duckham, of Baysham Court, Ross.

The *Devon Cattle* form a well-defined race of uniform red colour, and of smaller size than Short-horns or Herefords. They are supposed by competent naturalists to be nearly allied to the modern type of *Bos primigenius*, seen in Chillingham Park, and therefore claim a direct descent from the ancient bovine inhabitants of the British forest. The breed is divided into the smaller and more symmetrical, mossy-coated, North Devon, and the larger, straight-haired cattle of the fertile vale of Taunton Deane. The breed has not extended widely in this

AYRSHIRE COW.

while the comparison of the cows by weighing presented these adjoined results:—

Cows.	No. of Class.	Average Age.		Average Live Weight.		
		yrs.	mths.	cwt.	qrs.	lbs.
Devons ...	4	3	1¾	13	3	14
Herefords ...	5	3	4½	14	0	8
Short-horns ...	10	3	1¾	16	0	12
Sussex	8	3	5	14	3	0
Devons ...	4	6	11¾	12	1	19
Herefords ...	6	6	6	16	2	5
Short-horns ...	6	7	8½	18	1	23
Sussex	4	6	4	15	2	24

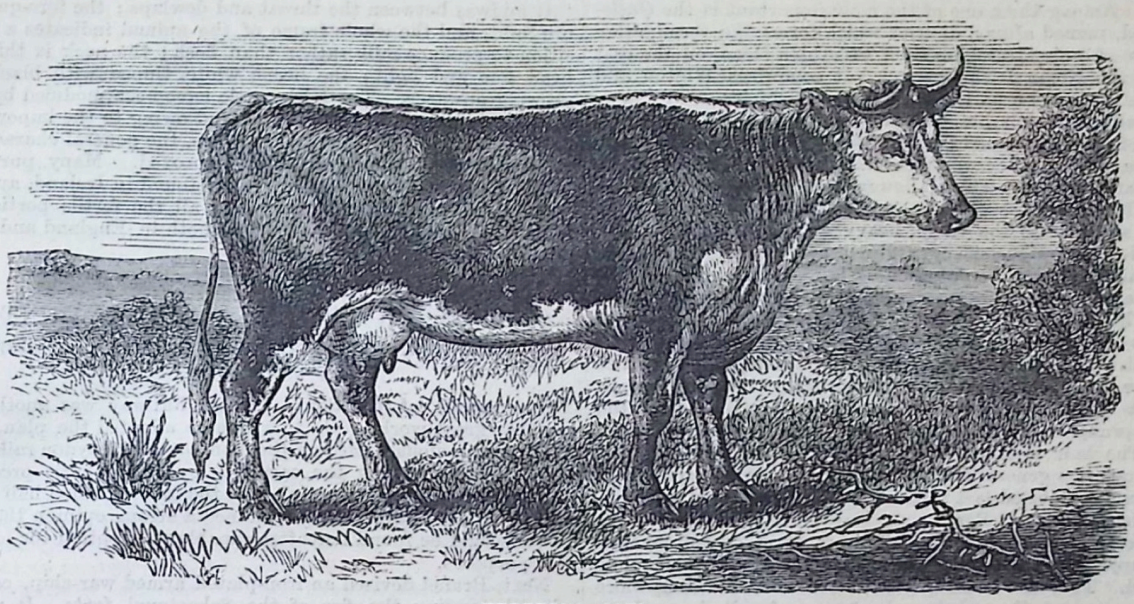
Mr. Duckham, editor of the "Hereford Herd Book," contests for the superiority of his favourite breed, and informs us through the columns of the above-named paper (May 21st, 1870) that at the Christmas meeting, 1868, the average weight of the Hereford steers not exceeding 2 years 6 months old was 10 st. 3 lbs. more than that of the Short-horns; whilst in the class not exceeding 3 years and 3 months old he is compelled to admit that the Short-horns exceeded the Herefords by an average of 5 stones (14 lbs. to the stone).

The beef of Hereford cattle is of fine marbled appearance, and of excellent quality, but the cows are poor milkers. The race is said to have been of uniform reddish-brown colour until the appearance of a white-faced bull calf about the middle of last century, from which the present Herefords are descended.

country, and is for the most part in the hands of a less wealthy class of men than the short-horn. Captain Tanner Davy, their historian, and the editor of the "Devon Herd Book," however, assures us that they have found a home in many counties of the United Kingdom, as well as in Mexico, Jamaica, Canada, Australia, France, and the United States. The general colour of the Devon cattle is red broken with white upon or near the udder only. The skin is of an orange-yellow colour, as is seen around the eyes and inside the ears. The horns are of medium length, and of fine waxy colour. The general form is light and graceful, but scarcely so good in the posterior as in the anterior portion of the body. The cows are famous rather for the richness than for the abundance of their milk. The Devon oxen are better adapted for the yoke than any other British race, and a pair of bullocks will plough in double harness, as the writer has himself seen. The *Sussex* cattle are very nearly allied to the Devons. They are stronger and coarser in head and horn, and larger in frame, but in all other points are identical with the Devons.

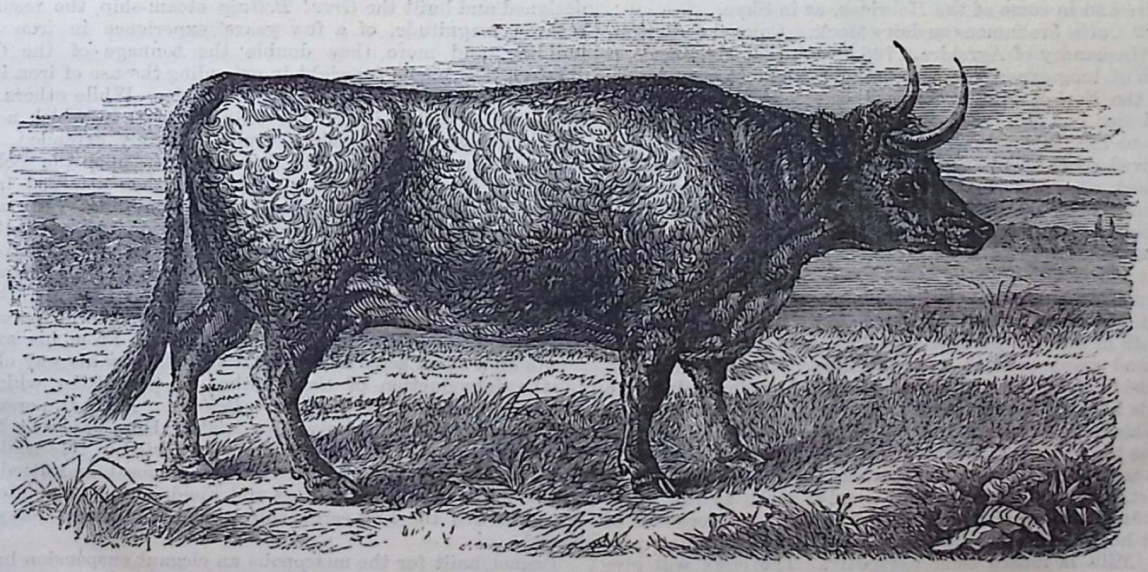
The *Long-horns* are chiefly interesting as a race which, after having been improved by the breeder's art, and introduced as the leading breed into almost every English county, has succumbed to a powerful rival whose very name appears to have been coined in a spirit of opposition—the Short-horn. These cattle originally were found by Bakewell in the fertile vale of Craven, in the West Riding of Yorkshire and eastern portion of Lancashire. Mr. Welby and Mr. Webster, of Canley, both obtained their stocks from Sir Thomas Gresley, of Drakelow

House, and this strain of blood subsequently came into the hands of the famous Leicestershire breeder, who, keeping in view the importance of beauty and utility of form, muscular development, and fattening qualities, brought out the new Leicesters, which soon became the favourite cattle of their day. They are thus described by Youatt. The fore-end long and light almost



HEREFORD COW.

to elegance; neck thin; chap, or under side of jaw, clean; the head long, fine, and tapering. Horns varying according to sex; in the bull from fifteen to twenty-four inches, and in the cow and steer from thirty to forty-two inches in length; the horns



WEST HIGHLAND COW.

turning down almost parallel with the cheeks, and in some cases turning inwards so as to require cutting, to prevent them from piercing the face of the animal. The colour, white along the back, and brindled brown and black on the sides. The Long-horns were imported into Ireland by Lord Massereene, the Marquis of Donegal, and Mr. Lesley, of Lesley Hill, and did much to improve and modify the native breeds of cattle there. He was also naturalised in Anglesea, where his descendants, still preserving the most characteristic traits of the breed, are yet to be found. Long-horns are still to be seen in the Midlands, and we may especially mention Mr. Chapman's herd at Upton, Warwickshire, as preserving the blood of the renowned bull "Twopenny."

Norfolk and Suffolk possess an excellent breed of polled, red cattle, supposed to have been derived from the polled Galloway cattle which have for long been favourites with the eastern counties' graziers. These animals are of uniform red colour, and are excellent milkers.

WELSH CATTLE.

Pembrokes.—These cattle are closely allied to the aboriginal cattle of this country; the White Forest breed, by mere change of colour, becoming similar to the modern Pembrokes (*Lowe*). The colour is black, broken upon and about the udder with white; the horns are fine, tapering, turned up at the points, and tipped with black; the skin is of a deep orange colour, sometimes approaching to black, as is seen on the naked portions of the body. The Pembroke may be looked upon as the type of all the mountain breeds of Wales, although he often appears as an unimproved and inferior type.

The Glamorgans have been crossed with the Herefords, to

which they now bear a strong resemblance. The cattle of Anglesea retain the appearance of the Long-horn, with which they were crossed during the dominance of that race.

SCOTCH BREEDS OF CATTLE.

Scotland is rich in native races, many of which are very distinctive. Among them one of the most important is the *Galloway* breed, named after a district which forms the termination of a range of hills stretching from St. Abb's Head, on the east coast, to the North Irish Channel. It comprises Wigton and Kirkcudbright, and a portion of Ayr and Dumfries.

The Galloway cattle are black and hornless (polled), and on account of this last-named peculiarity, as well as their fattening properties, are great favourites with graziers, especially in Norfolk and Suffolk. The Galloway cattle are peculiar for a wonderful compactness of form, great length, uniform breadth from the shoulder to the rump, heavy well-fleshed thighs, and deep well-sprung ribs. They are not a large breed, but will often attain to heavy weights. Closely resembling the Galloway is the *polled* or *clodded Angus* or *black Aberdeenshire* race. They are higher on their legs, and altogether larger and somewhat less closely grown beasts than the last, with scarcely so much coat. They are black, occasionally broken with a little white near the udder; hornless; characterised by great length and great width across the shoulder-tops, continued backwards by well-sprung ribs, and good loins without prominent hook-bones. The hair is short and glossy, and the skin soft and thick. Such is a general description taken by the writer from prize animals exhibited last year at the Highland and Agricultural Society's Show at Perth.

The *West Highland Cattle* or *Kyloes* form a well-marked race occupying all the mountainous region after which they are named. They are small in size; have horns turning more or less upward at the points; short muscular limbs, and are thickly covered with hair. Their muzzle is usually black; the hair on the neck (mane) is long; their colour varies from mouse, or even silver grey, to reddish brown and black; they are hardier than any other race of British cattle, and their size varies according to the richness or poverty of the district in which they occur. The finest specimens are found in parts of Argyleshire and in some of the Hebrides, as in Skye.

Ayrshire Cattle are famous as dairy stock. Colonel Fullerton, in "The Husbandry of Ayrshire, 1793," says that Mr. Bruce, a gentleman of long experience, dates their origin to cows introduced by the Earl of Marchmont, who succeeded to his title in 1724, and died in 1740. The varied colour and other peculiarities point to the Holderness breed (the immediate progenitor of the improved short-horn) as probably the original stock which was crossed with the native breed, giving as the result the Ayrshires. These cattle are rather small in size, varying in colour from white with a little red, to red with a little white, and again from a fawn colour broken with white, to almost black and white.

The typical Ayrshire cow is formed for milk. Her long fine head and upturned horns are succeeded by a thin neck, no great depth of bosom, shoulder-tops and crops narrow, ribs well sprung, and great breadth over the hips. Again, looking at the broadside of the animal, the depth should gradually increase backwards towards the flanks, giving what is termed the wedge form. This is much insisted on by all Ayrshire breeders, and it signifies the gradual thickening of the animal from the set-on of the head, where the neck is light, to the base of the neck, the breast, the girth, and the still greater depth at the flank. This gradual deepening contrasts with the heavy fore-end of the short-horn, and indicates milking, rather than feeding properties. Milk is indeed their speciality. The cows will give five gallons per day for two or three months, three gallons for three months, and one and a-half gallons for four months. Mr. Aiton rates the annual yield of milk at 1,000 gallons, but Mr. Ranken considers from 700 to 850 gallons as rather more than an average cow will give.

IRISH CATTLE.

The droves of Irish cattle brought over to our fairs in such large numbers every year have rendered these hardy and useful animals familiar to the eyes of Englishmen. The late Professor Lowe says the native breeds of Irish cattle may be divided into those of the mountains, moors, and bogs, and those of the richer plains with intermixed breeds resulting from the union of different races. Among the most distinctive of these mountain cattle is the Kerry breed, good alike for milk and for beef. The *Kerry* cow, as figured in Professor Lowe's "Domestic Animals," is of a yellowish-red colour broken with white on the bosom, belly, and udder; the hair is abundant, and forms a tuft midway between the throat and dewlaps; the fore-quarters are light, and the whole frame of the animal indicates a disposition to produce milk rather than flesh; the neck is thin, the head fine and light; the horns white, tipped with black, and growing upwards. The Irish cattle have been modified by both the long-horn and the short-horn, and owing to the importation of the latter breed during late years, the general character of the Irish cattle has been much improved. Many pure-bred herds of short-horns also are to be found in Ireland, and this breed seems destined to spread over all the fertile portions of the country, as it has already done both in England and Scotland.

NOTABLE INVENTIONS AND INVENTORS.

XXXI.—ISAMBARD KINGDOM BRUNEL (*continued*).

BY JOHN TIMBS.

THE sea-wall of the South Devon Railway was another of Brunel's great works. On this line he adopted the plan which had been previously tried on the London and Croydon railway—namely, of propelling the carriages by atmospheric pressure; but this proved unsuccessful, and the loss exceeded half a million of money. Still, he entertained a strong opinion that this power would be found hereafter capable of adoption for locomotive purposes.

Next, Brunel devised an iron-plated armed war-ship, capable of withstanding the fire of the Sebastopol forts. It was in connection with the interests of the Great Western Railway that Brunel first conceived the building of a steam-ship to run between England and America. The vessel was built accordingly; its power and tonnage was about double that of the largest ship afloat at the time of her construction; it was propelled by paddle-wheels, and named the *Great Western*. Next, Brunel designed and built the *Great Britain* steam-ship, the result, as regards magnitude, of a few years' experience in iron ship-building, and more than double the tonnage of the *Great Western*. Brunel's foresight in extending the use of iron in the construction of ships was very remarkable. While others hesitated, he saw that it was the only material in which a very great increase of dimensions could be safely extended. The very accident which befell the *Great Britain* upon the rocks in Dundrum Bay showed the skill he had then attained in the adaptation of iron to the purposes of ship-building. The means taken, under Brunel's immediate direction, to protect the stupendous vessel from the injury of winds and waves attracted deserved attention, and they proved successful, for the vessel was again floated. Nor must it be forgotten that Mr. Brunel was the first man of eminence in his profession who perceived the capabilities of the screw as a propeller. From his experiments on a small scale in the *Archimedes* he saw his way clearly to the introduction of that method of propulsion which he afterwards adopted in the *Great Britain*. He next persuaded the Admiralty Board to give it a trial in Her Majesty's Navy, under his direction. He was much thwarted in this trial, but the *Rattler*, subsequently placed at his disposal, and fitted with engine and screw, by Maudslay and Field, was a complete success, and was the first screw-ship which the British Navy possessed.

Brunel built for the metropolis an elegant suspension bridge, from Hungerford Market to Belvidere Road, Lambeth—a fine specimen of mechanical skill. It consisted of two lofty brick piers or towers, in the Italian style, 58 feet above the road, and built in brickwork and cement, connected by inverted arches at the bottom, and built on the natural bed of the river, without piles. For the foundation of the abutments piles, 26 feet long, were driven in an inclined direction. In the upper part of these towers four chains passed over rollers, so as to equalise the strain; they carried the roadway seven feet higher than the crown of the centre arch of Waterloo Bridge, with single suspension rods, the chains being secured in tunnels at the abutments to iron girders, embedded in brickwork and cement.

There were three spans, the central one between the piers being 110 feet wider than the Menai Bridge, and second only to the span of the wire suspension bridge, which is 900 feet. Brunel's bridge was built without any scaffolding but a few ropes, consequently without impediment to the navigation of the river; the cost was £110,000. The bridge was taken down in 1863, and the chains were carried to Clifton for the suspension bridge erecting there. In November, 1843, the bridge was sold to the original proprietors for the sum of £226,000, but only the first instalment was paid, and the purchase was thus void. The height above the piers was 21½ feet. Thus was gained additional height for the river traffic and a graceful curve, with the appearance of swagging prevented.

During the Russian war Brunel fitted up the Renikoi hospital on the Dardanelles. He laid on a special supply of water from the adjacent hills, and constructed short lines of railway with easy carriages, to facilitate the removal of the wounded from the landing-place to the different wards.

In the year 1851, prepared by experience and much personal devotion to steam navigation, Mr. Brunel began to work out the idea he had long entertained, that to make long voyages economically and speedily by steam required the vessels to be large enough to carry the coal for the entire voyage, and unless the facilities for obtaining coal were very great at the outport, for the return voyage also; and that vessels much larger than any built could be navigated with great advantage from the mere effects of size. Hence originated the *Great Eastern*. "The mere idea of a ship of a capacity six or eight times that of anything afloat had doubtless occurred to many an enthusiastic schemer; but Mr. Brunel gave shape to his idea by preparing plans, and otherwise convincing himself of its practicability. As an example of naval construction the *Great Eastern* is, unquestionably, the work of Mr. Scott Russell; yet Mr. Brunel's services were hardly of less importance, and every one at all conversant with the organisation of an establishment devoted to the construction of steam-vessels is aware that the duties of the naval architect and builder and those of the engineer are each clearly defined, and in no way conflicting; and certain it is that Mr. Brunel's name will be indelibly associated with the *history* of the *Great Eastern*, as long as that shall survive."

The success of this stupendous work, in a practical point of view, is admitted, as well as the strength and stability of the construction of the vessel. The difficulties attendant on the launching of the ship in 1858 at one time seemed insurmountable. To a friend, who despondingly expressed his fears that the huge ship would never reach the water, Brunel quietly replied, "Oh, she shall move; she must!" He never for a moment despaired of success. His health, however, had long been impaired by over-exertion, and his death was hastened by the fatigue and mental strain caused by his efforts to superintend the completion of the great ship. By a coincidence, as it would appear, Mr. Brunel went on board the great ship for the last time on the day when it could be said she was ready for sea. If not so in every detail, she was, as a whole, essentially completed, although still untried. On that day, the 5th of September, Mr. Brunel was stricken down by paralysis, from which he never recovered. He sank until the evening of the 15th of September, when he passed away, still young, and upon the completion of the greatest work of his life.

In the Patents' Museum, South Kensington, is a model of the Leviathan Steamship, as it was first called, constructed on the wave principle and lines of Mr. Scott Russell, for the Eastern Steam Navigation Company. The following are the principal details:—Length, 680 feet; breadth, 83 feet; depth, 58 feet; tonnage, 23,000 tons; nominal horse-power of paddlewheel engines (Scott Russell and Co.), 1,000 horse-power; nominal horse-power of screw engines (Watt and Co.), 1,600 horse-power; draught of water (light), 18 feet; draught of water (laded), 28 feet.

Mr. Brunel died at his paternal house at Westminster. He was a Fellow of the Royal Society, having been elected at the early age of twenty-six. He was the President of the Institution of Civil Engineers, and Vice-President of the Society of Arts; a Fellow of the Astronomical, Geographical, and Geological Societies, and a Chevalier of the Legion of Honour. "He lived and died with a scientific reputation, bounded only by the limits of the civilised world. He has left too many monuments of himself, raised both on land and sea, to permit of his being soon forgotten."

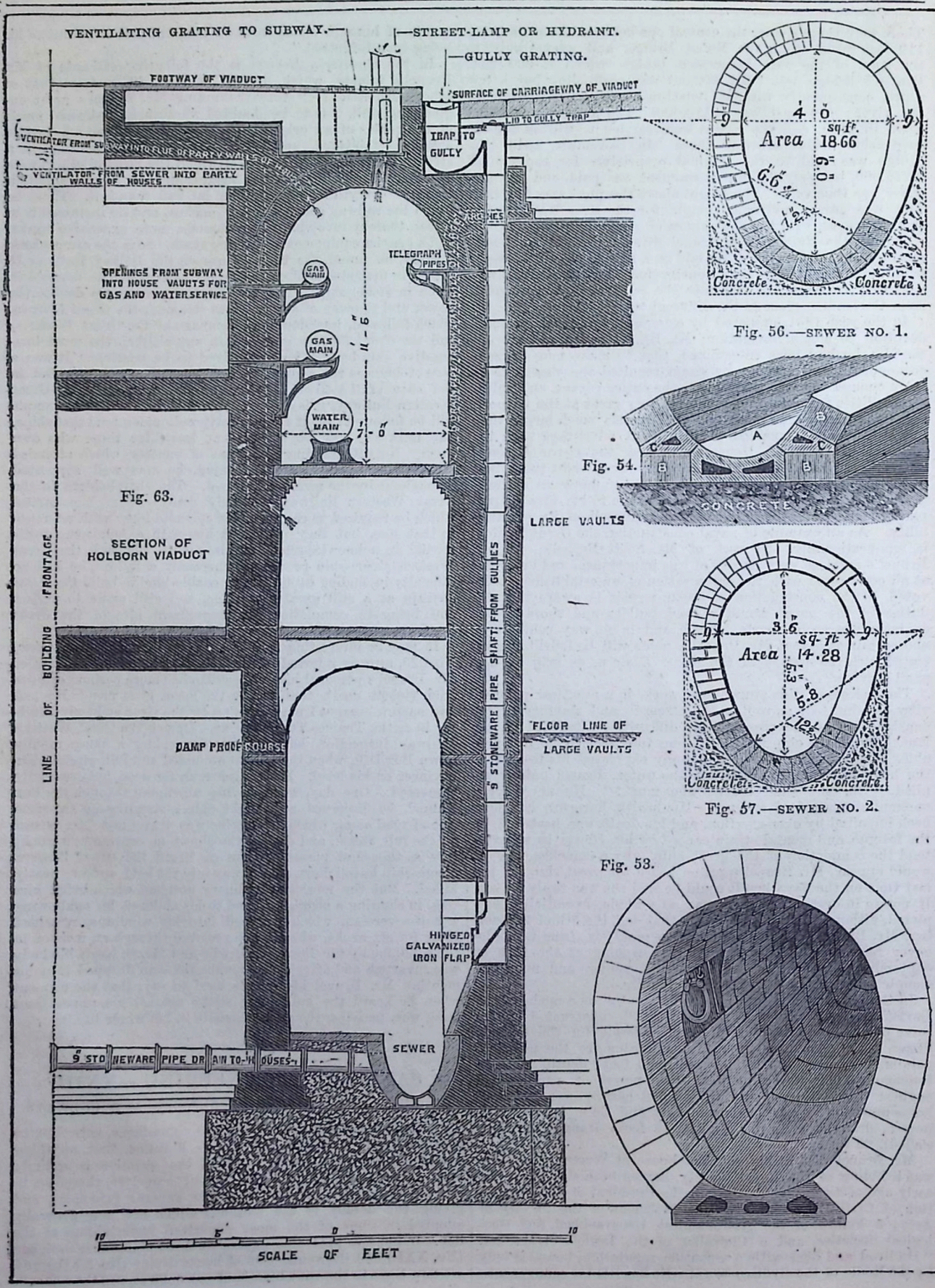
In the *Quarterly Review* is the following estimate of Mr. Brunel's talents, which, it will be seen, differs from that of other authorities:—"Notwithstanding Mr. Brunel's great engineering skill, it is to be doubted whether he possessed much of the genius of an original inventor. He took up a principle already established, and pushed it farther, exhibiting in a striking light the development of which the ideas of others were capable. His ruling idea was magnitude: he had an ambition to make everything bigger than he had found it. Thus, he found the railway gauge 4 feet 8½ inches, and he increased it to 7 feet, thereby involving wider tunnels, more expensive works, and a heavier equipment in working stock. So in the atmospheric railway, he found the tube in use on the Dalkey Railway 15 inches in diameter, and on the South Devon line he doubled it. Then in steam-ships the *Great Western* was nearly double the power and tonnage of any previous steamer; the *Great Britain*, which followed, was double the tonnage of the *Great Western*; and the *Great Eastern* exceeded in size all that the most imaginative ship-builder had conceived to be possible. It was a race of bigness run against himself as well as others. But in the case of the *Great Eastern* steam-ship, as of the Great Western Railway, it is not probable that Mr. Brunel's example will be followed; for it is now pretty well understood that ships, like railways, may be *too big*—at least, for those who own them. Notwithstanding the want of success which attended Mr. Brunel's principal undertaking, he was well supported throughout by the moneyed interest. The shareholders in the Great Western Railway not only readily found the capital which he required to carry out his splendid ideas with reference to that line, but they presented him with a handsome testimonial in acknowledgment of his genius. Though the *Great Western* steam-ship proved commercially a failure, he had no difficulty in finding capitalists to enable him to build the *Great Britain* at a still greater sacrifice, and still again to project and bring to completion his magnificent idea of the *Great Eastern* steam-ship."

It may be interesting to abridge from the *Quarterly Review*, No. 223, already referred to, the following singular incidents of Mr. Brunel's personal history:—"He had more perilous escapes from violent death than fall to the lot of most men. He had two narrow escapes from drowning by the river suddenly bursting in on the Thames Tunnel works. During the Great Western Railway inspection he was one day riding a pony rapidly down Box Hill, when the animal stumbled and fell, pitching the engineer on his head. He was taken up for dead, but eventually recovered. One day, when driving an engine through the Box Tunnel, he discerned some light object standing on the same line of road along which his engine was travelling. He turned on the full steam, and dashed the object (a contractor's truck) into a thousand pieces. When on board the *Great Western* steam-ship he fell down a hatchway into the hold, and was nearly killed. But the most extraordinary accident which befell him was, in showing a sleight-of-hand to his children, his swallowing a half-sovereign, which dropped into his windpipe, remained there for six weeks, when it was removed through an incision in the windpipe by Sir Benjamin Brodie and Mr. S. Key; his body was inverted, and after a few coughs the coin dropped into his mouth. Mr. Brunel afterwards used to say, that the moment when he heard the gold piece strike against his upper front teeth was, perhaps, the most exquisite in his whole life."

SANITARY ENGINEERING.—XXIII.

ON THE CONSTRUCTION OF SEWERS AND SUBWAYS.

THE literature of sewer-building is so voluminous, extending to many volumes octavo in our public libraries, that anything approaching a complete analysis of the question is entirely beyond our limits. We shall content ourselves, therefore, in the present paper by stating a few general principles, and giving the details of the methods which are now generally adopted in some of the most important undertakings of the day. In our two preceding papers we dealt with house drainage (No. XXI.) and the ventilation of house drains (No. XXII.), and we now come to the next branch of our subject, *i.e.*, the common


VENTILATING GRATING TO SUBWAY.
STREET-LAMP OR HYDRANT.
GULLY GRATING.
FOOTWAY OF VIADUCT
SURFACE OF CARRIAGEWAY OF VIADUCT
LID TO GULLY TRAP
TRAP TO GULLY
VENTILATOR FROM SUBWAY INTO FLUE DEPARTY WALLS OF HOUSE
VENTILATOR FROM SEWER INTO PARTY WALLS OF HOUSES
ARCHES
TELEGRAPH PIPES
OPENINGS FROM SUBWAY INTO HOUSE VAULTS FOR GAS AND WATER SERVICE
GAS MAIN
GAS MAIN
WATER MAIN
11 - 6
7 - 0
Fig. 63.
SECTION OF HOLBORN VIADUCT
LINE OF BUILDING FRONTAGE
LARGE VAULTS
9" STONEWARE PIPE SHAFT FROM GULLIES
FLOOR LINE OF LARGE VAULTS
DAMP PROOF COURSE
HINGED GALVANIZED IRON FLAP
SEWER
9" STONEWARE PIPE DRAIN TO HOUSES
10 5 0 10
SCALE OF FEET
Area
sq. ft. 18.66
4 0
6.6
Concrete
Concrete
Fig. 56.—SEWER NO. 1.
Fig. 54.
A
B
C
CONCRETE
Area
sq. ft. 14.28
3 6
5.8
Concrete
Concrete
Fig. 57.—SEWER NO. 2.
Fig. 53.

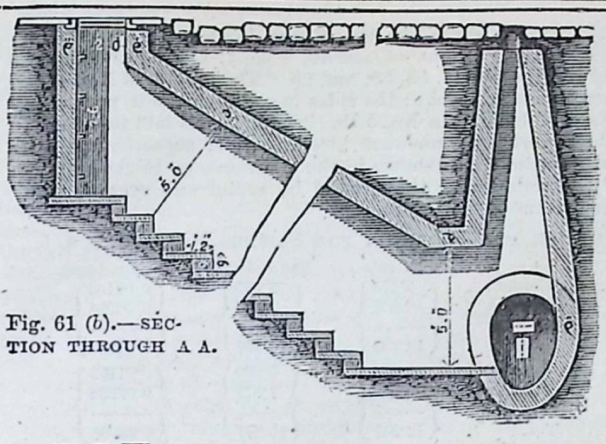


Fig. 61 (*b*).—SECTION THROUGH A A.

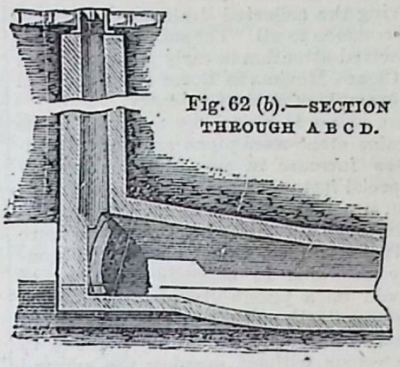


Fig. 62 (*b*).—SECTION THROUGH A B C D.

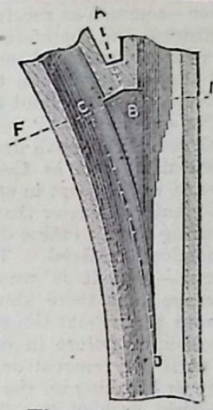


Fig. 62 (*a*).—BELL-MOUTH JUNCTION.

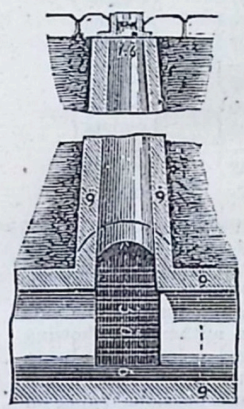


Fig. 61 (*c*).—SECTION THROUGH CC.

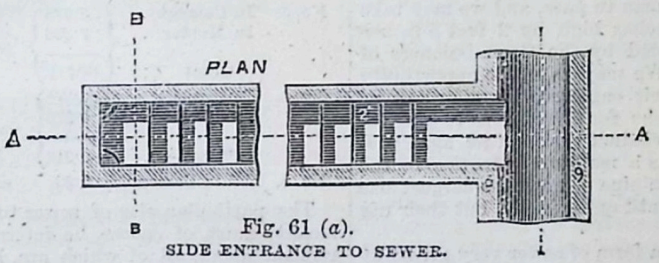


Fig. 61 (*a*).
SIDE ENTRANCE TO SEWER.

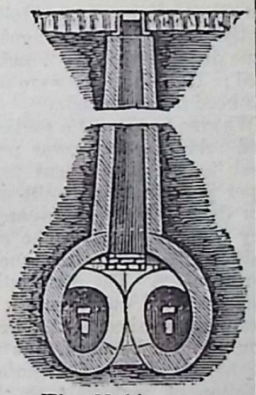


Fig. 62 (*c*)—SECTION THROUGH E B F.

Fig. 60.—SEWER NO. 5.

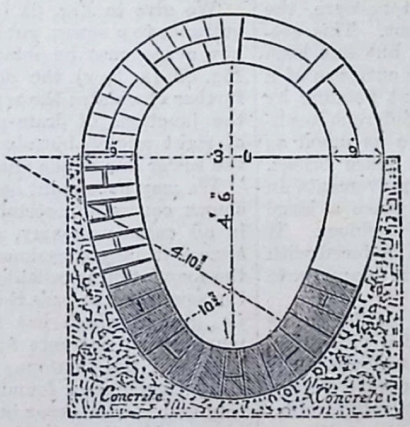


Fig. 58.—SEWER NO. 3.

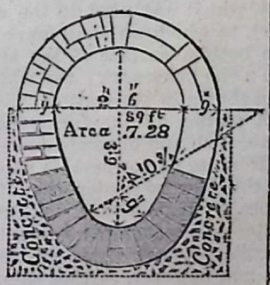


Fig. 59.—SEWER NO. 4.

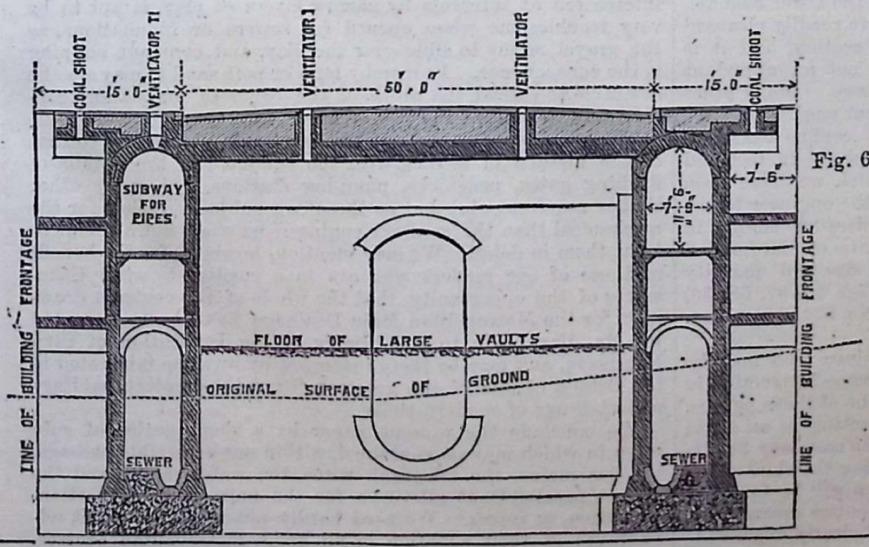


Fig. 64.

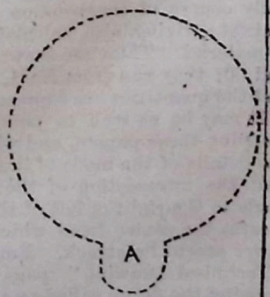


Fig. 55.

sewer—common as receiving the collected drainage of a street or district, and therefore common to all. The subject in itself is no new one, as it had received attention in early Roman times; and the remains of the Cloaca Maxima in Rome itself are still visible, a most excellent example of ancient masonry.

The question that first arises is as to the material to be employed. For small drains stone-ware pipes are now in universal use; but as these increase in size they increase in expense, and, except in special instances, are not to be obtained of a greater diameter than two feet, and the difficulty of manufacturing them to these dimensions renders brickwork the more economical material. There is also this point to be considered—that it is very desirable in extensive systems of sewerage that there should be a possibility of access from without throughout the sewer itself, so that in case of any obstruction, or failure in construction, it should be possible to get at it for removal or repair without opening the ground above or breaking up the course of the sewer itself. With a pipe-drain even of two feet diameter this is impossible, as the size must be sufficient to allow a man to pass, and we may take the minimum size as 3 feet 6 inches high by 2 feet 3 inches wide, the size now usually adopted by the Commissioners of Sewers of the City of London. We may take the opportunity here to thank Mr. Haywood, their engineer, for affording us this information of detail, and also for allowing us to publish the illustrations of the Holborn viaduct to which we shall presently refer. We may mention, as a matter of practice in the same district, that a 12-inch drain-pipe is now the largest size used; 15-inch pipes were used until quite lately, but their use has been discontinued.

We give in Fig. 53 a section of a form of sewer very generally used—showing the lower portion of the section as an "invert block"—specially burnt for the purpose in stone-ware, the upper portion being built of brickwork in cement. This section does not apply to any particular locality, but has been very generally used. The sketch shows the side entrance of a drain protected by a stone-ware trap to prevent flooding by storm-waters. The materials, of course, vary in different localities; we here only remark that they should be as much as possible non-absorbent. Soft, commonly called place bricks, should never be used, but the many recent improvements in the harder class of manufacture of late years place a large selection of materials at the command of the engineer. If possible, the internal surface of the sewer should be faced with glazed bricks, which are now readily obtainable in many parts of the country.

Fig. 54 represents a form of invert somewhat similar to the last, which was used in the sewers of the Holborn Valley district, to which we shall have occasion further to allude. A is the bottom surface of the sewer, C C is the stone-ware invert, B B B the brickwork; the whole laid upon the concrete foundation shown in the section.

A section of the form shown in Fig. 55 has been strongly advocated, and denominated self-flushing, as the lower channel, A, from its narrowness, is supposed to be more readily cleansed by the flow of water than the plain oval section, and it is probable that in dry districts which have not an abundant water-supply it may be adopted with advantage. Many other peculiarities of section are adopted by different engineers. We do not, however, further allude to these, but confine ourselves to authentic examples of sewers now extensively in use, and proceed to give a series of sections with which we have been furnished from the office of Mr. Bazalgette, the engineer to the Metropolitan Board, representing various sizes of sewers in daily course of construction in different parts of the London district; giving, also, calculated data as to size and quantity of material. These are shown in section in Figs. 56, 57, 58, 59, and 60; they run from No. 1, the largest, to No. 5, the smallest, and the quantities are expressed in decimals.

It may be as well to point out to any artisan who may be studying these papers, and who may require some instruction in the details of the mode of drawing the sections of these figures, that the intersection of the dotted lines meeting in an acute angle to the right or left of the diagram as the case may be, indicates the centre from which the arcs forming the sides of the sewer are to be struck. Further information will be found in "Technical Drawing" (page 15), where the entire operation of drawing the figure called an oval is fully and clearly explained.

The following gives the quantity of brickwork per foot-run in each of the sections of sewers, Nos. 1, 2, 3, 4, and 5, exhibited in Figs. 56, 57, 58, 59, and 60. The inverts of Nos. 1, 2, 3, 4, are in cement blocks; the sides in sound stocks in mortar in Old English bond. In No. 5 the bricks are all laid in cement, and the invert is a stoneware block. All of these sewers are bedded in concrete, as shown in the diagrams, up to the springing of the arch, unless the ground be sound and excavated to the exact form of the invert.

BRICKWORK PER FOOT-RUN FOR SEWERS NOS. 1, 2, 3, 4, 5.

		Feet cube.		*Feet reduced.*		*Rods reduced.*
No. 1.	In Cement .	3·375		3·000		0·01103
	In Mortar .	10·357	=	9·206	=	0·03385
	Total .	13·732		12·206		0·04488
No. 2.	In Cement .	3·375		3·000		0·01103
	In Mortar .	8·862	=	7·877	=	0·02896
	Total .	12·237		10·877		0·03999
No. 3.	In Cement .	3·375		3·000		0·01103
	In Mortar .	7·366	=	6·547	=	0·02407
	Total .	10·741		9·547		0·03510
No. 4.	In Cement .	3·375		3·000		0·01103
	In Mortar .	5·870	=	5·218	=	0·01918
	Total .	9·245		8·218		0·03021
No. 5.	All in Cement	5·93	=	5·27	=	0·01936

The particular size of sewer to be adopted in any particular locality must, of course, be determined by an infinite variety of circumstances, all of which are, however, a matter of calculation, and are readily ascertained by the experienced engineer.

We give in Fig. 61 (*a*, *b*, *c*), a section and plan of the side entrance to a sewer, published by the same authorities, showing how access may be obtained at any required points, and also in Fig. 62 (*a*, *b*, *c*) the details of a bell-mouth junction, which further elucidates the remarks we made in a previous paper on the junctions of drain-pipes, that these should never be made at right angles, but always in curves gradually coinciding with the sewer line in the direction of its current.

We may here point out that in the various sections of sewers shown concrete in certain proportions is provided. This is not in all cases necessary, and especially in the case of smaller sewers it may occasionally be dispensed with, when, however, the foundation is reliable—of good sound gravel or clay; but if the sewer has to pass through what is called "made ground"—*i.e.*, ground which has been disturbed and filled in again—a much larger concrete foundation should be provided than that shown in the sections; and we here remark that one of the most treacherous foundations is a piece of ground in which clay and gravel occur in alternate layers—a formation not uncommon in the neighbourhood of London, especially on the southern side. A bed of gravel, perhaps, on the side of a hill, intersected at intervals by narrow layers of clay, is apt to be very troublesome when opened for sewers or foundations, as the gravel seems to slide over the clay, and constant slipping is the consequence. In marshy land or soft sand it may also be desirable to extend the width of the concrete foundation considerably to prevent the risk of subsidence.

The question of sewer construction leads necessarily to that of the method of dealing with the sewage, and the details of flushing gates, penstocks, pumping stations, and many other similar requirements; but as these are subjects rather for the mechanical than the sanitary engineer, we shall not attempt to treat them in detail. We may mention, however, for the benefit of those of our readers who are in a position to avail themselves of the opportunity, that the whole of the contract drawings for the Metropolitan Main Drainage have been presented by Mr. Bazalgette to the library of the Institution of Civil Engineers, and may be there inspected by any one interested in the details of one of the greatest, if not the greatest, sanitary undertakings of modern times.

We conclude the present paper by a short notice of subways, in which may be contained, within one accessible passage, the gas mains, the telegraph wires, the water mains, and the sewers, accessible at all times for the purpose of inspection, alteration, or repair. We need hardly point out the great advantages of their adoption in all great metropolitan centres,

where the wealth and extent of the community render their introduction possible; but as the limits of our paper are nearly reached, we conclude it with a reference to two diagrams (Figs. 63, 64), showing two sections of portions of the Holborn Viaduct district, and clearly indicating the general arrangement. The larger section, that of the Holborn Viaduct (shown in Fig. 63), is no doubt exceptional from its extreme height; but we prefer illustrating, by this sketch in our present paper, a large undertaking recently carried out in all its details with thorough success, to laying before our readers drawings which, though perhaps more generally applicable to ordinary circumstances, have never been actually carried out in practice. It will be evident that, did our space allow, we might refer to many of our previous papers on gas, water supply, drainage, traps, and other points alluded to in the course of our present series; but the sections with which Mr. Haywood has favoured us are so clear in themselves, that if our previous papers have been read the drawings will easily explain themselves.

Our next paper will deal with the question of the ventilation of sewers, when we shall have again to acknowledge our obligation to the same authority.

GREAT MANUFACTURES OF LITTLE THINGS.—IX.

NAILS.

BY CHARLES HIBBS.

When Hutton, the historian of Birmingham, first approached the town he was afterwards to describe with so much humour and graphic power, he "was surprised at the prodigious number of blacksmiths' shops upon the road; and could not conceive how a country, though populous, could support so many people of the same occupation. In some of these shops," he goes on to say, "I observed one or more females wielding the hammer with all the grace of their sex. Struck with the novelty, I inquired, 'Whether the ladies in this country shod horses?' but was answered with a smile, 'They are nailers.'" At the time Hutton writes of, it is probable that the nail-making industry was carried on under conditions very similar to those which prevail in Belgium and some parts of France at this day, where a semi-agricultural population, occupying small holdings in the neighbourhood of the large towns, and deriving part of their subsistence from the soil, fill up their long hours of leisure by working at their own homes at some mechanical occupation, in which all the family can join. Cultivating a large patch of garden ground, or perhaps a small dairy farm, the Staffordshire nailer, and his wife, and his sons and daughters, used up all their spare moments in the nail-shop behind the house; and on the market day the good wife, clad probably in a man's flannel jacket over her looped-up gown, would trudge beside the donkey-cart to the nearest market town, perhaps eight or ten miles distant, and there dispose of her butter, and take the week's work of the family to the nail warehouse, where it was weighed in and paid for, and a fresh supply of nail rods given out for the next week. They were a hardy and laborious people, much given, it must be owned, to deep potations of ale, and lamentably ignorant; the children being put to the nail-block as soon as they were able to grasp a hammer, and even before that time they were made useful in blowing the bellows. In the course of time, as the district became honeycombed with coal-mines, the market gardens and the dairy farms were swept away, but the nail industry remained, and became the sole support of many a family. At one period it was computed that 60,000 persons were earning their subsistence at nail-making, and, as times were, their wages were fairly good. Large contracts for tea-chest nails came annually from the East India Dock Company; the Admiralty took between 600 and 700 tons a year; a large trade was done with Canada and the United States; and with the home demand these were generally sufficient to keep the nailer in constant work the whole year round. He had his seasons of holiday, during which it would have been sacrilege to strike a blow. The most notable of these was the wake, when, like the Dane at Yule, he

> "gorged upon the half-dressed steer,
> Caroused in seas of sable beer;"

and made merry, in his uncouth way, with bull-baiting, and such barbarous sports, the whole week through, to pinch for it a fortnight after. When work was going on briskly there was many a less cheerful scene than that presented by the nail district, comprising Dudley, Darlaston, West Bromwich, Oldbury, Rowley, Tipton, Bilston, and Wednesbury on the one side, and Stourbridge, with the adjacent district, known by the euphonious title of the Lye-waste, on the other. On a murk winter's night, when the sky was all aglow with the fires from the blast-furnaces, and the lurid flame, invisible by day, of some ignited pit mound, the music of the nailing hammers might be heard all the country round. From the little huts or sheds, dotted here and there upon the broken landscape with an utter absence of order or convenience, as though the mighty geological operations underneath had shaken them into the most unlikely places, the gleam of the hearth-fires would shine from the open shutters, and the merry songs of the workers, male and female, sung at the very topmost pitch of their voices, might be heard a mile away. Up to ten or eleven o'clock at night would these sounds continue—no uncommon circumstance in a district where labour never seems to rest, but where the roaring furnaces and the great rolling wheels go on unceasingly, day and night. Through the open loop-hole the whole art and mystery of nail-making could be witnessed by any passer-by. The nailer would have the ends of three or four rods in the fire, and taking out the one which had been in longest, after a pull or two at the bellows to bring it to a welding heat, he would taper down the point upon his anvil, at the same time making a shoulder for the head. He would then hold it over a chisel or cutting-punch, stuck upright at the side of his anvil, and, giving it one tap with his hammer, cut it half-way through; an iron stop in front of the punch giving him the exact gauge for the length. He would then turn down the point of the half-severed nail into a steel instrument called a *bore* (the top of which formed a mould for the head), and twist it off, and then, with a few smart blows, he would beat it down until the head was spread out sufficiently, and assumed the required shape, the nail just turning from red to black as he gave it the finishing tap. As his rods got too short, he would weld or "shut" two of them together, and put a new rod in the fire, and so on, with the regularity of clock-work, probably in a thousand nails not once varying the number of blows upon each. A great feat in the trade was making nails so minute as to be scarcely perceptible with the naked eye. A quantity were shown at the Exhibition of 1851, which, being put upon clean white paper, looked like so many grains of dust; but which, when examined through a microscope, appeared well-formed and perfect nails, each with the marks of seven distinct blows upon the head. A veteran nailer was attached to his hammer as a cricketer to a favourite bat: its haft was made to suit him, and he could work with no other; but with it he could perform wonders. Hutton, the historian before mentioned, said that the hammermen of Staffordshire were so skilful that he verily believed they could forge images upon the anvil.

Nail rods were produced by rolling iron, in the first place, into plates of the proper thickness, and afterwards passing these under *slitting* rollers, which split them into long square rods. Odd pieces of this material may be seen in the nail district serving various purposes, not the least frequent of which is that of tying the parts of a pig-stye together. There are various qualities and sizes, to suit the different varieties of nails, the best being used for making horse-nails, which require to be exceedingly tough and fibrous to admit of being driven into the hoof without breaking. Old horse-nails were at one time used extensively in the manufacture of the best gun-barrels, partly because the iron of which they were composed was of known good quality, and partly, it was supposed, from some additional property of toughness they acquired in the horse's hoof. It is probable, however, that the only advantage so derived was a guarantee that they were real horse-nails, and that they had stood the test of use—a guarantee which modern fraudful ingenuity has rendered valueless, for sham horse-nails, not to be distinguished from real, have been thrown in large quantities upon the market. Wheelwrights require good nails; so do hurdle-makers. There are as many as 3,000 different kinds of nails distinguishable by name—such as clasp, clout, and counter-clout; rose, dog, brads, tacks, etc. "A ten-pound

rose" would signify a rose-nail, of which a thousand would weigh ten pounds. Each locality produces its own special kinds; and a factor who would deal in all descriptions of nails must draw his supplies from widely separated places.

The first account of nail-making machinery occurs in the Patent Records of 1790, when one John Clifford obtained a patent for rolling them. He had a pair of rolls, cut all round with a series of nail moulds or matrices, heads and tails together, one-half of the impression in each roll, so that the rod came out converted into a string of nails, which required to be separated by cutting nippers. This plan was, of course, only available for the larger sizes, though he described it in his specification as "an entire new mode of manufacturing nails of every kind by machinery, never before made use of for that purpose." The same inventor afterwards took out a patent for punching nails from plates of iron, which was rolled taper for the purpose, having a thick side and a thin one. A punch and die, having the same taper, cut out spikes from these plates, and the heads were afterwards "upset," as the term goes, by another operation. This was coming nearer to the present method.

Guppy's patent, in 1796, was for cutting nails from plates by means of passing them under a roller having two cutters fixed at two opposite parts of its circumference. Underneath the roller was a movable piece called a vibrator, fitted with a die, which came in its motion under the cutters, and enabled them to cut off a piece the shape of a long thin wedge from the plate. This was then conveyed, by what the specification describes as "a chain calculated for the purpose," to a vice, which tightened up as it received it, held it while three taps of a hammer were given to it to upset the head, and afterwards opened out and let it fall; the whole being effected by one revolution of a wheel. This must have been a somewhat ingenious machine.

Visitors to the Workmen's International Exhibition of 1870 will have seen, among the machinery in motion, the modern process of nail-cutting. A girl sits in front of a press worked by steam, holding a strip of iron in a pair of long pliers, the handles of which are tightened up to retain it firmly; and turning it over rapidly at each stroke, a continuous stream of well-shaped nails falls from the machine, the head of one being formed from the point of the next, and *vice versâ*. The formation of the die and punch is somewhat peculiar. In the bed of the press is cut a square oblong hole, in which a punch of the same shape works, filling it exactly, and forming a solid block of steel, rising and falling with the motion of the press. The punch never rises entirely out of the hole, but on its under side is cut a step, the shape of the nail to be produced, and the girl inserts the strip of sheet-iron under this step as it clears itself from the hole, pressing the end of the strip against the solid part, and the sharp edges of the step cut off the nail. This arrangement causes the machine to work rigidly, and avoids bending the nail. Those small tacks called sparrowbills, which are much used by shoemakers, and have no projecting head, are most easily cut by this process; while sprigs, which have a head projecting to one side, are also formed with great neatness and regularity. On putting two of these together, head to point, it will be found that they fit into each other with extreme nicety. More complex machines there are, one of which we shall presently attempt to describe, which avoid this alternate process by a feeding apparatus which vibrates from side to side; while others, which make nails of different shape, have a supplementary contrivance for forming the head. There are few kinds of nails which cannot now be formed by machinery, and the trade in them is enormous, though probably not nearly so many hands are employed as in the best days of the hand-made nail-trade.

The revolution in the nail manufacture was completed by the introduction of an elaborate automaton machine, patented by Messrs. Ledsam and Jones, in 1827. A massive rigid framework, in shape like the skeleton of an oblong table, sustained, in the first place, a shaft working underneath, with a crank in its centre, which gave motion to the upper machinery, and was itself set in motion by a band-pulley at the end of the frame. On the top of the table were two massive slides, working in grooves, moving horizontally opposite ways from the centre. Motion was communicated to them from the crank by means of a rod and a toggle or knee-joint, which it is necessary to pause and describe. It consisted of two separate arms or levers, hinged together at one end, and the other ends hinged to the two sliders. When the crank-rod was connected at one end to the crank itself, and at the other end to the central hinge of this knee-joint, of course every revolution of the crank would cause the knee alternately to bend and straighten, and by consequence cause the sliders to move backwards and forwards. When it was at the upper part of its revolution the knee would be bent upwards, and when it was at the lower part it would be bent downwards; while at the middle part the knee would be perfectly straight. The nature of the motion gave almost irresistible impetus to the sliders, especially at the moment when the knee-joint was assuming the straight position. The reader has seen the very common children's toy, a box of wooden soldiers, with a slight jointed framework on which they can be stuck, and which elongates and contracts by moving the ends which are held in the fingers; this is simply a combination of toggle-joints. The sliders were fitted with cutters of rhomboidal shape, which could be fixed and taken out at pleasure, and were held firmly in their position by screws. As the sliders moved in their grooves, the sharp front edges of the cutters passed immediately under the corresponding edges of two other cutters, fixed rigidly in a position overhanging the frame. So far the cutting part of the machinery; what remained constituted the feeding apparatus. Hung to the frame we have described was a second oscillating frame, enclosing and overhanging it, which derived its motion from an excentric fixed on the crank-shaft. Through grooves in the upper part of this frame the strips of iron to be cut descended gradually to the level of the cutters, being held upright by means of rods depending from a beam overhead. A holder received the upper end of the strip, and this holder could be so fixed upon the depending rod as to slide down it by its own gravity, being weighted sufficiently for that purpose, and to allow of the strip of iron falling at a sufficient rate of speed as it was cut away. The business of the oscillating frame was to present the strip to the cutters at such an angle as to allow of a perfect nail being cut off, and the only attention which the machine required was the putting in of fresh strips, as the old ones were cut to the stump. Not the least ingenious part of the machine was the excentric, which could be adjusted to suit every size of nail by a screw, the head of which could be reached with a spanner.

Nails which required to be headed after they were cut, were subject to a defect arising from the extreme squeeze which was required to be given to them to hold them sufficiently tight for the head to be formed when cold. To obviate this a manufacturer, named Kingham, patented an improved machine in 1868, the object of which is thus set forth in his specification:—"The ordinary machine-cut nail is so griped while being headed that it is pressed out of shape, being of different form and often smaller immediately under the head than at a short distance below it; while the nail made by my improved machine is griped by dies so made and operated that the symmetry of the nail is preserved, or, in fact, improved; the shank being pyramidal, and thus suited for boat-building and other purposes."

The history of the hand-made nail trade since the introduction of machinery is a sad record of strife and disaster; abject poverty on the part of the workers, and often cruel oppression on the part of the employers. The numbers engaged have dwindled from 60,000 to less than 20,000, and the wages of those left in almost the same proportion. He is a clever nailer who can earn 12s. a week; and the labour of the whole family scarcely suffices to keep body and soul together. The Factory Act is inoperative in these districts, the work being done still at the nailers' own homes, which makes legal inspection and supervision practically impossible, and the poor untaught children are put to work at the very earliest age, for the sake of the few pence they are able to earn, thus bringing up another generation to cling hopelessly to a declining industry. Wages are largely paid in truck, in defiance of the law, and the number of respectable money-paying firms is constantly on the decline. The poor workman is often glad to exchange his morning's make of nails for a meal at the truck shop, or he is compelled to accept a little credit, from which moment the truck-master has him under his thumb. The cash-paying masters have often tried to put an end to the infamous truck system, but in vain; and the competition of the truck masters in the market compels them unwillingly to lower the wages of their work-people. To their honour be it said, they have not done so

without endeavouring on several occasions to make a public stand against it. At a meeting of nail-masters held in 1842, the following resolution was passed :—

"That, although this meeting is informed that some masters have been reducing wages for some time past, it is the opinion of this meeting that wages, as already fixed by the masters, are low enough, and they entreat those masters to give the full amount of wages, thereby preventing that distress which must otherwise follow such practices."

No trade has suffered so much from strikes; and a memorable one which took place shortly after the meeting referred to, led to the military being called out and the Riot Act read. Seldom has a strike resulted in anything but a further reduction; and the prospects of the future trade may be estimated, when it is stated that some descriptions of machine-made nails can be sold for one-fifth of the price of those that are hand-made, although the price of these last is not one-half of what it was.

Still it is supposed that there will always be a demand for some kinds of hand-made nails, and there are some which cannot be produced of sufficient quality in any other way. Among these are horse-nails, and in this branch wages were even greatly advanced during the period we speak of. It has been found impossible to get the requisite amount of toughness otherwise than by working the metal under the hammer, and this being the case, workmen are able to command a fair remuneration for their labour. Still the trade gives employment to comparatively few.

Copper nails, or nails cast from a mixture of copper with some cheaper alloy, are much used in ship-building, and especially for fastening on the sheathing to the bottoms of vessels. It was found that when the heads were left rough the ship's bottom fouled much faster than usual, and that a barnacle was sticking to every nail. The heads of these nails have, therefore, to be turned and smoothed in a lathe.

CAPITAL AND LABOUR.—II.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

POSITION OF THE QUESTION IN ENGLAND (*continued*).

It is very unfortunate that the hopes to which we drew attention at the close of our first paper on this important subject have been raised, for assuredly they will not and they cannot be gratified. A government is never, except for very short periods, in advance of the opinions entertained by those whose affairs it administers. No reform in the ways or habits of any society can ever be achieved except by those powers which lie within society itself, and which may be aroused or strengthened by the presence of those occasions on which they can be exercised, and by the heads and hands of those who understand and wield them.

In England the case has been very different. Here the habit of spontaneous agency, of self-government, of association, of combined action is so strong and so familiar, that no sensible person in this country expects that a government should do more than take away hindrances to such combination and association—should attempt anything beyond giving as much liberty as is consistent with order and quiet. English people, therefore, rarely expect that the government under which they live should take in hand the settling of their condition by finding employment for unoccupied hands, still less that it should re-distribute the wealth which the various individuals of which society is composed have collected. In other words, they expect, provided only that action is free and law is fair, that the condition of each person, and his share in the general product of labour, will be settled by competition, or arrangement, or contract.

Unfortunately, law has not, in times past at least, been at all fair. For nearly five hundred years the English law, though it put no hindrance in the way of employers, so as to prevent them from making the best bargains they could, put very serious hindrances in the way of labourers. The beginning of this system was the occurrence of a sudden scarcity of labour, and a consequent rise in its price. In order if possible to check the rise, laws were enacted forbidding employers to give, and labourers to receive, more than the wages which prevailed before the scarcity occurred. In time a different expedient was adopted in order to attain the same end. The magistrates were empowered to fix the rates of wages at their quarter-sessions. In other words, the employers of labour were allowed to determine by law what they might choose to pay their workmen, and the workmen were obliged to be content with the allowance which was made them. At the same time any association of workmen, which had for its object the discovery and employment of means by which the rate of wages might be heightened, was *strictly prohibited* and *severely punished*.

It is one of the consequences of an unwise or unfair law—those two words being in legislation almost synonymous—that the evil it does lasts long after its abrogation. The fact that this legislation was directed against the workmen, and that it stood in the way of attempts on their part to better their condition, left permanent feelings of suspicion and distrust in the minds of the labourers—of suspicion and alarm in the minds of the employers. There is no country in the world which has witnessed so many disputes and bickerings as England has in its various industries. Sometimes they took the form of riots and machine-burning, sometimes of strikes and lock-outs. On the whole, perhaps, the rate of wages earned by skilled artisans is greater, and the hours of labour are shorter, than in any European country, not indeed that the former are too great, or the latter too light. But there is no other European country in which there have been so many bitter and angry disputes between employer and workman.

Another reason why the relations of labour and capital (using the words in their popular meaning as denoting the bargains between employer and workman) have occupied so much space in social and economical philosophy, is the fact that the line between employer and workman is drawn with far greater strictness in England than it is elsewhere. In one kind of industry the line is seldom overpassed by the workman. It is very rarely the case that an agricultural labourer succeeds in becoming a tenant-farmer. In other industries it constantly happens that the workman tries to become an employer, or at least to work on his own account. This is particularly the case in those callings which are very widely distributed, and for which there is consequently a very general demand, such as the building trades. But in several callings it is seldom the case that the workman in England rises to be an employer. He is apt to remain permanently in his condition.

The case is very different in other countries. In Germany, for example, the workman on his own account is the rule, the capitalist employer and the hired labourer the exception. England is the country of large capitals, custom, and much more law, assisting in the aggregation of wealth, and discouraging its distribution. Now whatever the word capital may mean, it always means wealth employed actively for the purpose of obtaining income or profit, as the case may be; and therefore, where large capitals exist, there always will be a tendency towards stereotyping the two classes of employers and workmen. Of course if the habit of association were to spring up among workmen, the capitals which many men could collect, as has been proved in certain co-operative undertakings, may become far in excess of the largest capital possessed by private proprietors.

There is one advantage, however, which the English law has given the labourer at all times. It has considered his wages as a secured debt. In other words, if the employer becomes bankrupt or insolvent, his labourers have a claim to be paid in full, before any part of his effects can be distributed among his other creditors. It is probable that the origin of this custom is to be found in those times in which the payment of labour was generally made by granting the occupation of land, or *vice versâ*, where the occupier of land paid labour in liquidation of his rent. But whether this be the cause of the custom, or it be assigned to some feeling of humanity, the practice has a defence, in the fact that the labourer, in so far as he advances his labour to his employer—as he generally does—has disposed of his whole property or capital to one man, and therefore would be put in a disadvantageous position by the side of any other creditor, who may be supposed to have lent only a portion, and a small portion, of his capital to his debtor.

There are, then, several reasons which may account for the prominence which the relations of labour and capital possess in the theory of English social life. Some of these reasons are derived from the freedom which characterises contracts and associations in this country, some are the consequences of our

law, some are derived from the peculiarities of our trade and manufactures.

PROFITS OF CAPITAL.

My reader will see that in the foregoing remarks I have used the words capital and capitalist to represent the resources and the function of the employer. But I have done so under protest. The workman, in so far as he possesses the strength and the skill necessary for the work which he undertakes, and in so far as he lends his labour to the employer, before he receives his wages, is just as effectually a capitalist as the employer is who hires him. Familiar usage, and the necessity of making a distinction between the two principal agents in most productive actions, render it convenient to speak of the employer as a capitalist, and the artisan as the workman, though both possess capital, and both do work.

The remuneration which the work of the capitalist obtains is called profit. It must not be imagined, however, that all that which he is enabled to appropriate as his share is paid him for the work which he does. He may employ the property of others, and pay interest for the loan. Now, interest is the reward which a man obtains for allowing another to use his property. In so far as the employer has property of his own, so he will expect and get interest for his property, as certainly as though he borrowed the property of other people; in just the same way as a man who cultivates his own land, receives, so to speak, rent from himself. The amount of interest which a person can get for the use of his property depends entirely on the quantity of property which can be lent, and the uses which borrowers can put such property to. If the property be scanty, and the desire to use it keen, the rate of interest is high. If, on the other hand, the property is abundant, and the wish to use it slight, the rate will be low. In neither case is it necessary that the profit of the employer should follow the rise and fall in the rate of interest. At the present moment, the rate of profit in many callings is very high, but the rate of interest is exceptionally low.

Again, part of the remuneration which the capitalist receives is security against risk. Business is ordinarily conducted in such a manner as that no loss occurs in the great majority of transactions; but no business is free from risks. Apart from the chance that a purchaser may be insolvent, and therefore be unable to pay his debts, there are risks that the manufacturer may have produced more than the market requires, or than the public fancies, or have offered something which nobody cares to purchase, or have made a loss in the purchase of his materials, or have made some other miscalculation. These chances are so numerous and so serious that it is not too much to say, that they who prosper in life generally do so, because they have contrived either by skill or good fortune to escape some of these losses which others, not so intelligent or so fortunate, have suffered. In such a case, the former gets an advantage from the losses of the latter. Business is calculated on the average of profit and loss, and the man who individually incurs the least loss, gets most profit.

Take out of the quantity which the employer of labour appropriates, that which he receives as interest on his property, and that which he lays by as a security against risk, and the residue is gained by him, because he gives pains and trouble, or, in other words, labour, to the calling in which he is engaged. It will be seen, therefore, that there is no economical difference between the true profits of the employer and the wages of the workman. Both are payments for work done, and both are made because work is done. Both are wages; and sometimes persons have spoken of the "wages of superintendence," as part of the profits of the employer. In reality, if the exposition given above is intelligible, profits are wages in disguise.

The distinction and similarity between profits and wages are no mere verbal limitations. It is wholly essential to a right understanding of the relations which subsist between labour and capital, that the resemblance between profits and wages should be recognised, for by this fact we are able to discover what there is at the bottom of all those struggles between labourer and capitalist, which are so constantly observed and commented on, but so little understood. In brief, these struggles generally consist in an attempt on the part of the employer to increase his rate of wages, and a similar endeavour on the part of the workman to increase his.

It is commonly said that profits tend to an equality. This statement is very imperfectly true. Interest not only tends to an equality, but, if the securities are equally good, actually makes an equality. Risks are not an equality, but an average. It is only because that part of what is called profits, which is really interest, and that part which is half insurance appear to be, and to a great extent are, equal in most callings, that this error of the tendency of profits to an equality has arisen. Wages do not tend to an equality, even when they are the wages of workmen; for they vary not only by reason of time and place, but much more by the comparative skill of the workman. Still more, however, do the wages of employers vary, because the skill of different employers varies exceedingly. One employer makes a fortune, another hardly gets a living. It is absurd to say that their profits are equal, or even tend to equality.

There are two ways in which greater profit, in the sense which I have assigned to this word, is made. One of them is by lessening cost; the other is by multiplying transactions. Different kinds of business give very different opportunities for these two sources of increased profit. It will be clear to every one how powerfully manufacturing profit is affected by the first of these processes. A piece of woollen cloth is woven at the present day for a tenth of the cost which was incurred a century ago. By a discovery that woollen rags could be used over again, the saving of cost in the manufacture is assisted by a saving of cost in the material. Now, as long as any lessening in the cost is the property of one man, it becomes his profit, and his only. As soon as it belongs to all other manufacturers, either the public will get the advantage, in the lowering of prices, or the labourer will share the boon in the increase of his wages. It will be plain, however, that the intelligence which lessens cost is a kind of labour, and a very important kind too.

It will be easy to illustrate the other manner in which the individual increases his profit. The labour of a stockbroker consists in purchasing securities on behalf of his customers, he receiving a fee in the form of a per-centage on the purchase or sale of the security. The business of the broker is to get as many of these commissions as he can; there is no limit to his power of doing such business. If a single broker kept clerks enough, he could buy and sell every pound's worth of the stocks and shares which change hands in the market. His function is to be known and to be trusted.

This leads me to point out what is meant by good-will. There are some kinds of business in which the connection between the trader or workman and his customer is so valuable, that if it be judiciously transferred, it will sell at a very great price. Instances of such a kind are the business of a banker in good repute, or an attorney who has what is called a good family connection. In both these cases considerable advantage is gained out of ordinary routine transactions, over which a general supervision on the part of the manager is all that is necessary. Of course the basis of this connection is a reputation for integrity and good faith.

The profits of trader and manufacturer are always highest in those countries which are rapidly growing in wealth. But they are highest in such countries, because the wages of all labour are high, provided of course that the labour is useful, and therefore in demand. Now this result occurs in the most marked manner when the business of such countries is brisk, and the resources are great. In no countries are profits higher than in such newly-settled regions as possess abundant land, the produce of which can be easily brought into the markets of those countries where population is abundant, and land fully occupied. Similarly, in a country like our own, where there are extraordinary opportunities for obtaining that increase of profit which comes from very numerous transactions on commission, large fortunes are made from that kind of business in which such commissions can be indefinitely extended.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVII.

BY E. WYNDHAM TARN, M.A.

BRINGING INTO BILL.

We now come to the last operation to be performed by the measuring surveyor, and the one for which all the previous

operations are only preparations; this is called bringing all the measurements into bill, and is performed by taking the several items *seriatim* from the abstract, and entering them in proper order on ruled bill-paper, so that the prices per yard, foot, rod, or each, can be attached to them, and the work priced out.

The following order should generally be observed in bringing into bill. Cubed articles to be placed first in each trade, then the superficials, then the runs, and lastly the numbers. It is also usual to begin with low-priced articles, and enter them in increasing order. These rules will be best explained by presenting our readers with a detailed bill of all the items contained in the abstracts previously given under the several trades.

BILL OF QUANTITIES.

EXCAVATOR.

YDS.	FT.	
74	5	Cube, digging in clay, 1 throw, and carting 1 mile
28½	0	,, ditto, ditto, 2 throws, part filled in and rammed, part wheeled two runs .
77¼	0	Ditto, ditto, in gravel, 2 throws, filling in and ramming . . . . .
12	8	Supl., clay puddling to vaults . . .
180½	0	,, levelling earth, average depth 12 in. .
41¼	0	Run, planking and strutting to trenches, 7 ft. 6 in. deep, 2 ft. 3 in. wide . .

WELL-SINKER.

FT.	
25	Run, digging and steining (dry) to well, 3 ft. diameter in the clear, gravel soil .
10	,, ditto, ditto, in mortar to cesspool, 6 ft. diameter in the clear, clay soil . .
40	,, boring through sandstone rock, with a 3-in. auger . . . . .

Carried to summary . . £

BRICKLAYER.

YDS.		
15¾		Cube, concrete in foundations, composed of 1 part lime to 6 parts ballast . .
49½		Supl., 6 in. concrete floor composed as above .
2½		,, ditto, 1 part Portland cement, and 8 parts ballast . . . . .
21¼		,, ditto . . . . .
		,, ditto in 9 in. walls, with use of apparatus
FT.		
23		Cube, stock brickwork in mortar to copper .
RODS.	FT.	
12	160	Supl., reduced stock brickwork in mortar .
195		,, ditto, fence walls . . . . .
YDS.		
34		,, brick nogging to partitions . . .
89¾		,, Malm facing . . . . .
112		,, tuck pointing . . . . .
231		,, flat joint pointing. . . . .
99½		,, ½-in. tile paving in cement . . .
7½		,, 1 brick vaulting in mortar . . .
4		,, brick on edge, paving in sand and grouted
FT.	IN.	
86	1	,, Asphalte . . . . .
76	8	,, Malm cutter arch . . . . .
20	5	,, cutting to splay . . . . .
18	0	,, ½ brick trimmer arch . . . .
31	0	Run, chamfer to brickwork . . . .
32	0	,, double tile creasing . . . .
65	0	,, extra to brick on edge coping in cement
22	6	,, cutting chase for rain-water pipe . .
60	0	,, 6 in. glazed ware socket-pipe drain, and jointing in cement . . . .
YDS.		
376		,, iron hooping as bond, $1\frac{1}{2}'' \times \frac{1}{16}''$ . .
		Number—
		6 flues cored . . . . .
		6 chimney pots, and setting in cement. .
		1 range setting . . . . .
		5 stoves ditto . . . . .
		12 sash-frames and door-cases, bedded and pointed. . . . .
		8 air-bricks . . . . .
		3 6-in. junctions to drains . . . .
		2 ditto bends ditto . . . . .
		1 ditto syphon-trap ditto . . . .

Carried to summary . . £

TECHNICAL DRAWING.—LXXIV.

DRAWING FOR BRICKLAYERS (*continued*).

We purpose in the present lesson giving some further illustrations of drawing.

Fig. 596 is a section of a drain of the oval form.

Before drawing this, it will be well that the student should be reminded that the difference between an ellipse and an oval is, that the former is equally curved at both ends, whilst the latter has the one end larger than the other, similar, in fact, to the form of an egg, and hence its name (from *ovum*, an egg). The following figure (Fig. 597) from "Practical Geometry applied to Linear Drawing" is here repeated in order to save trouble of reference:—

To construct an oval, the width A B being given. Bisect A B by the line C D, cutting A B in E. From E, with the radius E A, draw a circle cutting C D in F. From A and B draw lines through F, and produce them indefinitely. From A and B, with radius A B, draw arcs cutting the last two lines in G and H. From F, with radius F G, describe the arc G H, to meet the arcs A G and B H, which will complete the oval.

Now in Fig. 597 it will be observed that only the width is given, whilst the depth at D is found by the radius of the arc drawn from F.

In Fig. 596, however, the height of the drain, as well as the width, is given.

In this drain the span is 3 feet and the height 4 feet 6

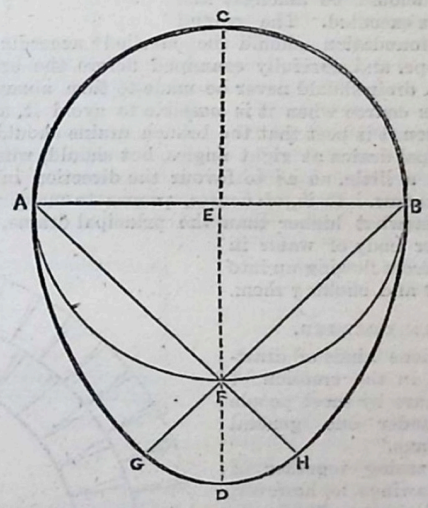


Fig. 597.

inches. The upper arch is a semicircle of 18 inches radius, and the lower curve is the third portion of a circle of 10¾ inches radius, the centre of which is of course set off on the centre line at the distance of the radius from the bottom. These two curves are united by arcs struck with a radius of 4 feet 10¾ inches, the centre being on the springing line produced.

The upper arch in this example is formed of two 4½-inch rings, with occasional whole bricks laid as headers, or bricks of a wedge-like form purposely moulded.

The sides of the drain are worked as rough arches in whole and half brick, the half brick being of course half in appearance only, the whole brick lying in the direction of the drain.

The lower arch is formed of bricks purposely moulded to the form, by which means the closest possible joint is obtained in that part of the drain through which the sewage is passing, and which should therefore be rendered absolutely impervious to water.

In relation to bricks purposely moulded as superseding rubbed bricks, we extract the following passage from Mr. Gilbert Redgrave's official report on this section of manufactures in the International Exhibition of 1871:—

"Much as we admire it, we cannot help considering rubbed brickwork to be false in principle. There is no doubt that rubbing has been resorted to in some of the most beautiful work which we possess, and we must admit the new buildings at South Kensington are most excellent examples of the judicious employment of red bricks. But we are convinced that as bricks are necessarily moulded in the process of manufacture, it is a mistake to tamper

with and shape them after they have left the kiln. It is really doing the work twice over to cut them into fantastic shapes when they might have received these forms in a quarter of the time while the clay was in a plastic state."

The following example (Fig. 598) is a section of the principal drain at King's Mews Barracks, near Charing Cross.

It is 2 feet 6 inches wide by 4 feet 9 inches high in the clear. The sides are straight for nearly three feet in height, and are one and a-half brick thick. The arch at top is a segment approaching to a semicircle, and at bottom a flat segment-arch is used. These arches are one brick thick. The foundation is level, and small buttresses (not shown in the figure) are added at intervals. In concluding this section it may be observed that all drains should be well considered before a building is commenced, and they should be amongst the first things executed. The ground for the foundation should be levelled according to the proper slope, and carefully examined before the brickwork is begun. A drain should never be made to turn abruptly in any part of its course when it is possible to avoid it, and for the same reason it is best that the branch drains should not enter the principal drains at right angles, but should, when possible, be slanted a little, so as to favour the direction in which the water is to flow. It is, of course, proper to make the branch drains somewhat higher than the principal drains, to prevent the greater body of water in the latter from flowing up into the former and choking them.

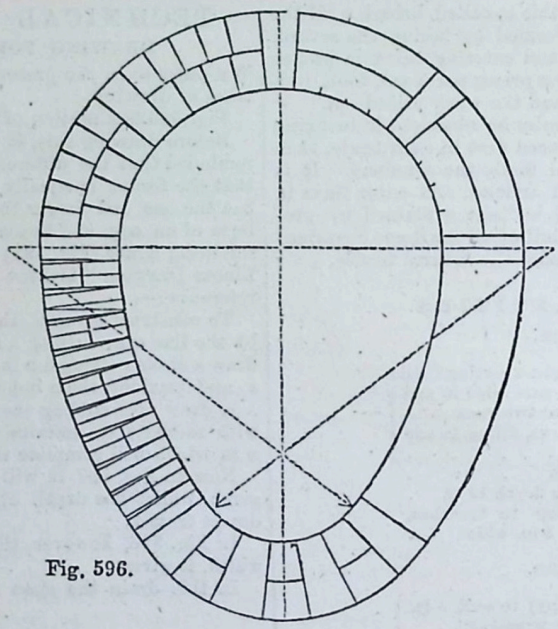


Fig. 596.

PLAN DRAWING.

The various kinds of drawings used in the erection of buildings are by most people classed under one general name, "plans."

This massing together of all the drawings is, however, wrong technically. The drawings consist of plans, elevations, sections, and working drawings. These have been already fully explained in "Building Construction," and need, therefore, be only briefly alluded to in this place. The plans, it will be remembered, are classed as—

1. Block plans: showing the mere outlines of the buildings, and their position in relation to the surrounding objects.

2. Excavation plans: showing the shape of the trenches to be dug for the foundations, cellars, underground kitchens, etc.

3. Basement plans: showing the foundations and works up to the level of the ground, or, as it is called, the ground line.

4. Floor plans: including (1) the ground-floor plan; (2) the chamber plans, showing the disposition of the different rooms, which are not always arranged as on the ground floor; but, of course, the main walls necessarily cause the general apportionment to be the same; other divisions are accomplished by means of partitions; and (3) the attic plan, showing how the garrets or attics are arranged.

5. Roof plans: showing the manner in which the roofs are disposed, so as to secure the fall required, that rain may at once pass off by the gutters and spouts.

Plans resemble the appearance of any object viewed from a height above it. They represent not only the piece of ground occupied, but the space it overhangs as well. This has been fully demonstrated in "Projection," in which the principle of projecting elevations from the plans has been fully worked out.

Plans, therefore, do not convey any notion as to the *appearance* of a building, but as to its *reality*. They do not show how the building looks, but how its different apartments are arranged. Nor are plans associated in the mind with what may have been seen; for, of course, a true view of a roof, such as would be given in a roof plan, could only be obtained from a point above it, looking immediately downwards.

Ground plans or foundation plans of buildings or other works do not give any just notion of the appearance of the object represented, because when a building is finished, it is impossible from any point of view whatever to see the various walls and foundations in the manner in which they must be represented in the ground plan, the whole of these parts being hidden by the very building reared upon them.

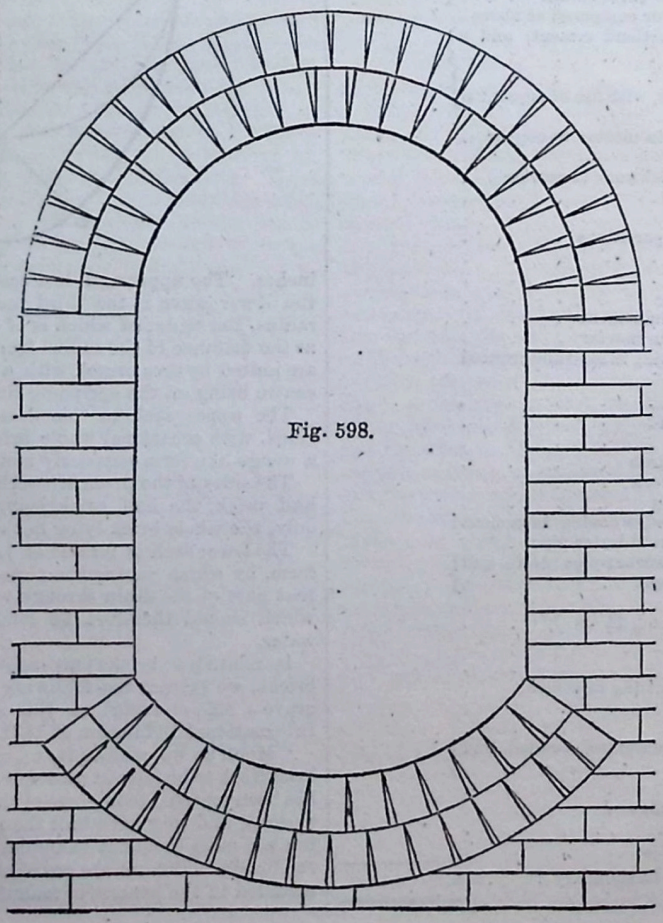


Fig. 598.

In fact, the ground plan of any finished building is, properly speaking, a section through the various walls; the only difference between it and a common section consisting in this: that the common section is taken vertically, whereas the actual section of a building which is exhibited in any ground plan of it is supposed to be taken *horizontally*. Thus, if the student can imagine a house cut through horizontally, immediately on the line of the first floor—that is, on the level of the top of the first flight of stairs—and the whole part above this cut including the floor to be removed, a drawing made of the edges of the walls, of the floors, and stairs they include, would be the plan of the ground floor.

Since, then, the elevations must be entirely dependent on the plans, the utmost care must be exercised by the student, not only in the design, but in copying such sets of drawings, since they must correspond with each other with the utmost degree of accuracy.

MINING AND QUARRYING.—XXVI.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

LEAD FUME—COMPOSITION—VALUE OF FUME—MODE OF COLLECTION—REDUCTION—SOFTENING OF LEAD—TREATMENT OF DROSS—NAPLES YELLOW—CHARACTERISTICS OF PURE LEAD.

In the last article the objectionable character of the waste gases from the lead-smelting works was briefly referred to. Those who have passed through the Swansea valley will have been impressed with the utter absence of any vegetation, which is due to the sulphurous acid evolved in the course of copper-smelting; but the destruction of all plant life is the only serious objection to the presence of copper works. It is not so with those where lead ores are treated: were they to be as near Swansea as the copper works are, and were the same low chimneys to be used, the town would be absolutely uninhabitable. The whole of the population would soon present symptoms of lead-poisoning.

It is the lead fume, as it is technically called, which must be prevented from passing into the atmosphere; the sulphurous acid gives no trouble to the lead-smelter. The lead fume, moreover, is of very considerable value, too great to allow of its being lost. In composition it varies somewhat, but the principal ingredient is always sulphate of lead, the proportion of which will range from 65 to 85 per cent. There is usually some oxide and sulphide of lead as well, the rest consisting of silica, lime, alumina, etc. As it comes away from the furnace it most probably consists of sulphide and oxide of lead, but as large quantities of sulphurous acid are being evolved at the same time, the latter combines with the lead salts above named, and converts them into the sulphate.

The fume when given off from the furnace appears as a dense white smoke, which gradually deposits a fine powder varying in colour from white to grey; but even after passing through all the arrangements made for its collection a sufficient quantity usually passes up the chimney to render it a characteristic feature of a lead-smelting establishment.

For this reason the chimney-stack is generally removed to a considerable distance from the works, and if possible to some piece of mountain or waste land. Thus the great chimneys of Mr. Beaumont's works at Allenheads form a conspicuous feature in the landscape for many miles round, being erected on the very summit of the high moorlands which rise above the works. The lofty chimneys of Pembrey, situated on the waste lands close upon the shore, form in like manner, with their dense white smoke, an equally conspicuous object from any part of Carmarthen Bay.

The fume has usually, however, a considerable journey to perform before it reaches the exit into the open air. At Allenheads, for instance, the aggregate length of the flues is about 9 miles, one of them alone measuring more than 2½ miles. They are carried horizontally, or nearly so, for a considerable distance, and then rise with the hill until they reach the chimneys on the top. The flues are built of masonry, and are 8 feet high by 6 wide. Doorways are made at intervals, which are opened on the occasions when the flues are cleaned out; and on one of these occasions the quantity of lead fume which was collected from them yielded no less than 800 tons of metallic lead. The value of lead saved by this means at these works alone amounts to about £10,000 per annum.

Sometimes large chambers are placed at intervals along the line of flues with the object of aiding the deposition of the fume by reducing the strength of the draught; but the fume appears to be in so very finely divided a state that they exercise no perceptible influence upon the quantity of deposit, which seems most readily arrested by friction against the sides of the flue. This opinion is supported by the fact which has been frequently noticed, that those parts of the flue which may be wet from the percolation of water do not contain so large a deposit of fume as those where the masonry or brickwork is quite dry.

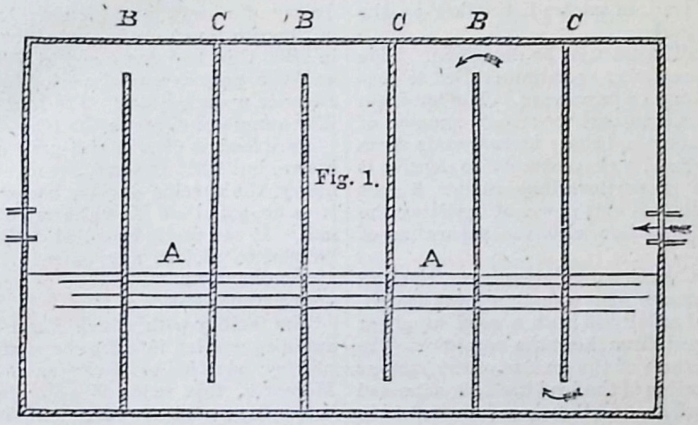


Fig. 1.

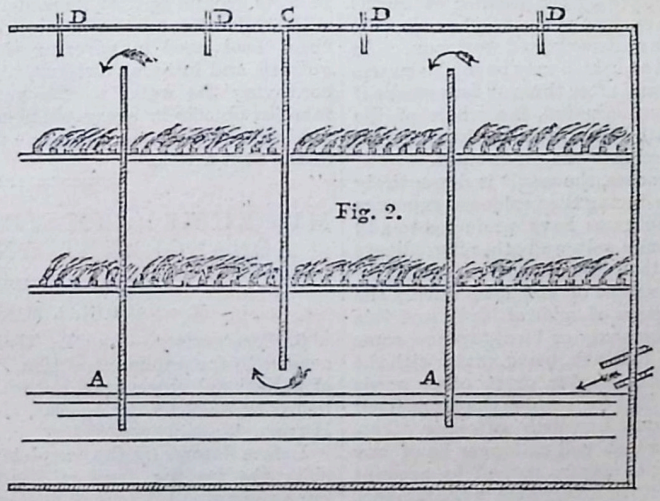


Fig. 2.

The first cost of flues of such enormous length, and the constant expenditure incurred in keeping them in repair, form no inconsiderable items; and various arrangements have been devised for artificially throwing down the fume, and so dispensing with the long flues. Some of them are found to work well, though the older plan still maintains its ground when the nature of the country is suitable; and in some cases a combination of the long flue and the condensing apparatus has been adopted with great advantage.

These artificial plans for condensing the fume almost always depend upon the agency of water applied in one way or another. They are called after the names of the inventors—Stagg's, Stokoe's, etc.; but it will not be necessary to go into all these in detail. In Stagg's condenser the fume is forced, by water or steam power, through water several times in succession, by making it pass through a chamber divided by horizontal partitions on the principle shown in the diagram (Fig. 1), in which A represents the level of the water, and B B B and C C C the two sets of partitions, the one set reaching nearly to the top, and the other nearly to the bottom, below the surface of the water, so that the fume will have to take the course indicated by the arrows.

In Stokoe's condenser, on the contrary, the water scarcely reaches up to the partitions C C, etc., so that the fume does not actually pass through the water at the bottom of the chamber, but each division has two floors made of open woodwork, upon which fagots are laid, as shown in Fig. 2: streams of water pour down continuously from the pipes D D, which become broken into showers as they trickle through the fagots, presenting a large surface of water to the fume as it also passes through them. A fan-blast is of sufficient power to work this apparatus.

In others a layer of pebbles is substituted for the fagots, and again in others jets or showers of water are thrown at intervals into the condensing chambers. Some of them are said to do their work so thoroughly that no ill effects are produced by the smoke when it issues from the chimney.

The quantity of lead fume given off in the course of the smelting seems to vary very considerably; probably from differences in the nature of the ore, as well as in the treatment. The lead extracted from the fume frequently amounts to 7 per cent. of the total quantity of metal produced at the works, and sometimes even to more than this proportion.

As the fume when collected consists almost entirely of sulphate, it is generally smelted in a reverberatory furnace with the addition of some coal and about an equal quantity of scrap iron; but owing to the finely divided state of the fume it cannot be put into the furnace without being first agglomerated into lumps, which is done either by gentle heating until it just becomes soft, or by mixing it with lime paste.

The greater portion of the lead produced by the various processes already described is not of a quality fit for the manufacturer, and is termed hard lead, in contradistinction to the finished article known as soft lead.

The refining of the hard lead must now be described. This operation goes by various names, being sometimes called softening, and at other times calcining or improving. The hardness of the lead is due to impurities, amongst the most common of which is the presence of antimony and zinc; these metals form alloys with the lead, and so alter its character as to deprive it of some of its most valuable properties: they render it less manageable under the roller, diminish its power of resisting the action of the atmosphere, and interfere with the separation of the silver from the lead.

In order to get rid of these objectionable ingredients, the lead is melted in a reverberatory furnace with a shallow level hearth, and kept for some little time at a dull red heat, a good supply of atmospheric air being maintained throughout the operation. The dross, which consists of a mixture of the oxides of the various metals, including also some portion of the lead itself, is skimmed off as it accumulates on the surface, and the metal is tested from time to time to ascertain when it has arrived at a proper condition of softness. The right period is known by the peculiar iridescent and crystalline appearance of the surface of the test sample as it cools, which is easily recognised by an experienced workman. As soon as this point has been arrived at, which may be in the course of twelve hours, or on the other hand after three or four weeks if the lead has been very much contaminated, the whole of the dross is skimmed off, and the metal drawn from the furnace into a pot, from which it is again ladled into the pig-moulds.

In this, which is the ordinary process, the result is due entirely to the slow oxidation of the metals during the prolonged exposure in the furnace; but some manufacturers have preferred to add nitrate of soda, caustic lime, common salt, and other ingredients which assist in the separation of the impurities.

The dross skimmed from the surface of the lead during the softening, contains a large proportion of oxide of lead; and this is again reduced in either a reverberatory or blast furnace, some coal, and occasionally also a little soda ash, being mixed with the charge. This will yield a lead still harder, or in other words still more full of impurities, than that from which the dross itself was derived; but it may nevertheless be worth softening. This will yield a still inferior dross, which will no longer be of any value to the lead-smelter, though it may be turned to account by converting it into the antimoniate of lead, which is the pigment known to painters as Naples yellow. This product may be obtained by the simple calcination of the dross at a red heat; though the brilliance of the colour is said to be improved by the addition of a good quantity of common salt during the latter part of the process, or by subsequently exposing the calcined article to the action of acetic, hydrochloric, or sulphuric acid.

In the first article upon this subject, attention was drawn to the fact of this being the great lead-producing country of Europe; but it appears from the statistics compiled by the Government that the home consumption of this metal is somewhat in excess of the production. According to the official returns for the year 1868, the quantity used in this country was calculated at 78,000 tons, while the quantity derived from the ore raised within the United Kingdom was only 71,000 tons. The balance has to be made up by imports from abroad, either of the ore or of the metal itself. In the course of the twelve-month a good deal of ore does come here from the Australian colonies and from foreign parts to be smelted; but although the produce of the country so nearly balances the home consumption, the total imports of the year above named amounted to 58,000 tons, and a large proportion of this was in the condition of pig-lead.

It seems anomalous that with all our advantages we should import such large quantities of the manufactured article, but the explanation will be found to lie in the fact that the pig-lead imported is the hard lead, which is brought to this country to be softened and subsequently desilverised. This is now a regular branch of trade carried on to a large extent on the banks of the river Tyne. The principal source of supply of this hard lead is Spain, where, though the ore is exceedingly abundant, the smelting processes are carried on under certain disadvantages, the ores being poor in quality and refractory in character, while fuel is so scarce in the lead-mining districts that the coke used in the smelting has to be sent out from this country.

The softening and desilverisation of foreign leads is an industry of recent introduction; in the year 1844 only 213 tons of Spanish lead were imported into Newcastle for this purpose; in 1852 this had increased to 7,317 tons; in 1862 to 12,459; and the next decennial period bids fair to show a considerable advance upon the last. The lead contains on an average about fifty ounces of silver to the ton.

Pure lead is of a bluish-grey colour with a bright metallic lustre, but this is soon lost on exposure to the air. It is very heavy, the specific gravity being 11·35; but on the other hand it is so soft that it can be readily scratched with one's finger-nail. It can easily be rolled out into thin sheets, and these may be bent to almost any extent without breaking. It melts at about 620° Fahrenheit, and as compared with other metals is a very bad conductor of heat.

The facility with which it can be rolled out into flat sheets, and also pressed into the shape of hollow tubes, coupled with its pliancy, have led to its very extensive application in these forms. Moreover, this mode of using lead was well understood long before the means of rolling zinc into plates was discovered, and though much more expensive than the latter, it will certainly hold its ground against its modern rival on account of the ease with which it can be manipulated by reason of its pliancy. The sheet lead used in covering the roofs of houses, in making gutters, and in lining cisterns, together with the lead piping for conveying the water to the various parts of our houses, are familiar objects in every plumber's shop. The mode by which pig-lead can be made to assume these forms must be considered in the next article.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

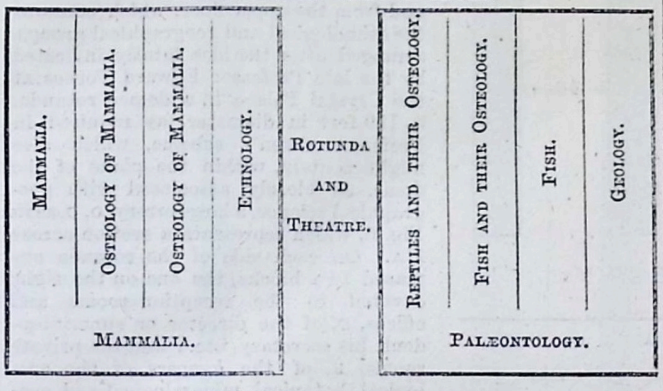
X.—NATIONAL MUSEUMS (*continued*).

6. *Construction.*—As Mr. Waterhouse's plans are not yet accessible for public inspection, I am forced to give an ideal plan of a National Museum of Natural History, founded on the published views of Owen, Agassiz, Hooker, Sclater, Flower, Archer, Huxley, Wallace, etc.

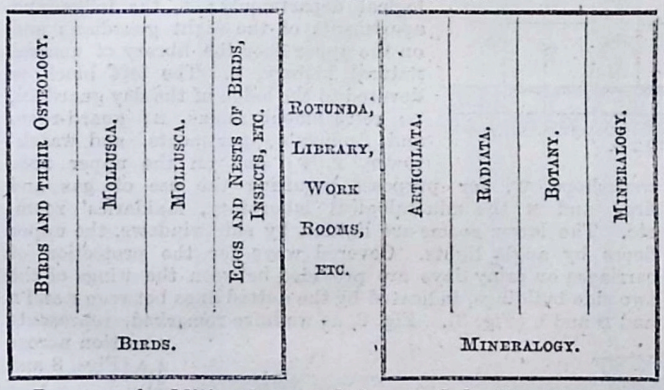
Before describing the complete building, it will be well to consider the leading ideas on the principles of construction that have suggested themselves to those naturalists who have given attention to the subject. First, as to date, is Professor Owen's plan of 1859, founded on the principles he had carried out in the construction of the new Hunterian Museum, built under his auspices during his conservatorship at the College of Surgeons, which answer the objects in view admirably—viz., the attainment of the perfect illumination of both wall and table cases by admitting daylight through windows placed in the angles formed between the walls and a flat roof, as shown at L in the section (Fig. 1). He considered that if space could not be given for the erection of the entire series of galleries on one floor, to allow of this principle of lighting being carried out, then light should be admitted by windows placed on each side of the lower galleries, immediately over the wall-cases, and to effect this he intersected the series of galleries with open courts 20 feet wide, as shown in the plan (Fig. 1). Professor Owen devoted the basement, B, to store-rooms, workshops for taxidermists, modellers, skeleton preparers, carpenters, etc. Over the basement he placed a range of galleries 30 feet high by 40 feet wide, with an average length of 150 feet, light being attained by the open courts referred to, C, C, of plan and section.

These side-lighted galleries he considered suited for the disposition of mammalia, reptiles, fish, ethnology, osteology, palæontology. Above the lower, he placed a second range of galleries, 25 feet high, lighted from the angles of the building, as at the College of Surgeons, which he deemed best fitted for the arrangement of birds, oology, mollusca, radiata, plants, minerals. The plan of 1862 consisted of a series of eight such galleries, 150 feet long, on each floor, with a rotunda for the lecture theatre, elementary collection, etc., in the centre, which were arranged thus:—

GROUND FLOOR—SIDE LIGHTED.



UPPER FLOOR—TOP LIGHTED.



In case of additional space being needed, the open courts could be covered in with arched glass roofs, at a height of 25 feet from the floor, so as not to interfere with the side windows of the lower galleries. Keeper's rooms and small studies were placed at the end of certain galleries, as indicated in K and S, in the plan (Fig. 1). It will be noted that the successive links in the chain of Nature are here arranged in broken or disconnected order, and that the requirements of the memorialists of 1858 are not complied with as to the direct blending of the osteological and palæontological with the recent specimens, or of the eggs, nests, etc., into the life-history groups of birds, insects, etc., though this is a matter of arrangement, not of building construction: the two subjects are so intimately connected that it will be advisable to call attention to it here. Fig. 1 gives a clear idea of Professor Owen's ideas on the construction of museums, which I understand is the type adopted by Government for the new building at South Kensington, on which Mr. Waterhouse's approved design is founded. Next in order, we have Dr. Philip Lutley Sclater's* ideas, as conveyed in a paper read before the British Association at Liverpool, September, 1870, entitled, "On Certain Principles to be Observed in the Establishment of a National Museum of Natural History." His plan is to arrange the building in the form of a hollow square, the external walls measuring some 600 feet by 400 feet, this external block being divided by a central wall or partition into two equal parts, the outer portion being devoted to the public galleries, the inner portion to the studies, keeper's and store-rooms, the centre of the hollow square being occupied by a circular building containing the library, having direct communication, by light iron galleries, with all the working-rooms, so that students of any department could obtain ready access to it and the lecture theatre. This museum might be of two, three, or four storeys, as the public galleries would be lighted by windows on the outer walls, and the studies, etc., by windows in the inner walls, the system of top lights being avoided. Dr. Sclater's plan of building will be readily understood on consulting Fig. 2. His system of arrangement must next be noted. Outside the partition that separates the studies from the galleries, he arranges a continuous line of wall-cases, for the display, in one unbroken series, of the "vertebrates, from the highest mammal to the lowest fish;" and so on, with the invertebrate, botanical, and mineralogical collections, or, as I suppose, in such manner as practical considerations might modify. The leading idea is that the fronts of these wall-cases should be hermetically glazed on the side exposed to the dusty atmosphere of the public galleries, and accessible only from the side next to the studies, to allow of any specimens required by students being removed from the cases containing the public series to the study-tables. This method had been previously suggested by Dr. Hooker, in a letter to the *Gardener's Chronicle*, as far back as 1858 (page 749 for that year); but as Dr. Sclater says, in a note to his paper, as published in *Nature*, for Oct. 6, 1870, "I can only, therefore, claim to be *an* (not *the*) original inventor of this method of arrangement." "These cases (says Dr. Hooker) should open from the back only, and then into smaller parallel side galleries, in which the naturalist might work undisturbed by the public." Further, he suggests that these cases should commence three feet above the floor, the space beneath being occupied by drawers, etc., opening into the back galleries, the space in the public galleries corresponding to the back of the drawers being utilised with diagrams, classifications, illustrative remarks for the instruction of the general public.

It will be observed that in Dr. Sclater's plan (Fig. 2) the wall-cases are reduplicated to obtain an extended range of wall-case in a gallery of limited length. Thus, as will be shown in Fig. 9, when in the ordinary way a wall-case would only present a frontage of 35 feet, by throwing out the cases 15 feet into the gallery, and doubling them on each other, a frontage of 95 feet may be obtained. To gain access to cases of this kind, it is necessary to provide a passage, at least 3 feet wide, nearly through the centre, to give access to the doors. It appears to me that the advantage gained by the hermetically closed fronts is to a great extent counteracted by the manner in which Dr. Sclater places these cases in the open public galleries, as the dust disturbed by the traffic would distribute itself over the top of the cases, and find access to the cases when the doors at the back were opened. It would be better to place these back close to the wall that separates the galleries from the studies, so that the backs of the cases formed the separating partition itself, and then it would be necessary to roof in the passages. This might be done by throwing a gallery over the projections, in a manner similar to that which may be seen at the Museum of Practical Geology, as indicated at G (Fig. 2); but the drawback therein experienced is the serious darkening of the cases at the end of each bay, and the increased difficulty of general supervision, as such covered recesses form covers for thieves and other objectionable characters, that, according to the evidence given before the Committee on Public Institutions,* must be provided against in our public galleries, especially those of great extent. The better plan would be to place the cases *at the end of the recesses*, under a beam or iron girder, stretching from pier to pier at 9 feet above the floor, of equal depth as such cases, say 3 feet, so as to bring the fronts flush with the upper part of the walls of the galleries, and the backs flush with the walls of the studies, then by roofing the projecting cases so as to cover the passages from the studies, the fronts would be really hermetically closed on the public side, and dust effectually excluded. My idea on this point is indicated at H (Fig. 2), and will be shown in detail in Figs. 7, 8. Dr. Wallace raises another objection to Dr. Sclater's plan, on the ground that the use of wall-cases on one side of a gallery for an entire museum is an expensive and wasteful principle of arrangement. The same might be said of devoting an equal width to the studies as to the public galleries, and on this point we might be guided

* Secretary to the Zoological Society of London.

* "Parliamentary Papers," Vol. XVI., 1860.

by Professor Maskelyne's opinion, that a depth of 25 feet from window to wall was essential for the instrumental requirements of the mineralogical private rooms.* Dr. Wallace raised other objections, but these were not associated with constructive details, and will be considered under the head of "Arrangements."

Typical Plan for National Museum of Natural History.—As Professor Owen's and Dr. Sclater's proposals embody the guiding ideas of British naturalists on museum construction, I will give the details of a plan that embraces the practical points of both systems. The main walls of the principal building would form a hollow parallelogram, as shown in Figs. 3 and 4. In elevation it would consist of a basement devoted to storage, workrooms, and workshops, wherein any operation *not requiring the use of fire or artificial light could be carried on.* The ground-floor would comprise the VERTEBRATE GALLERIES, 30 feet high by 50 feet wide, lighted by windows on the outer side, placed at 10 feet above the ground, and studies, store, and keeper's rooms, etc., running parallel with such galleries, in two tiers 15 feet high by 25 feet wide, lighted by windows looking out into the open court, with doors on the lower tier opening into the public galleries pertaining to the same CLASS of objects. The walls that separate the galleries from the studies being pierced to allow of wall-cases being employed in the manner shown in my next paper (Figs. 7, 8). All the lower tiers of studies would communicate one with the other by doors fixed in the walls that separate one CLASS from another, to give the student ready access from one CLASS to another. On the ground-floor a single-storeyed gallery, *lighted from above*, devoted to the proper display of birds, would intersect the open court. The upper floor would be arranged on the same principle, but be lighted entirely from above by angle windows. The galleries would be 25 feet high by 50 feet wide; the studies 10 feet high. This floor would be approached by wide staircases, S, S, at each end of the building, rising from the halls, H, H. Fig. 5 shows a section of the entire building, across B B, with the method of reflecting light into the windows of the basement, by means of white tiles placed at an angle. On entering at th main entrance, H, and turning to the left, the MAMMALIAN GALLERY (I.), 1,100 feet in length, would have to be traversed; then the AVIAN GALLERY (II.), 700 feet; the REPTILIAN (III.) and PISCEAN GALLERIES (IV.), with a united length of 1,100 feet; ascending to the upper floor the INVERTEBRATE GALLERY (V.), 950 feet long; next the Botanical Gallery (VI.), 200 feet long, with its Herbaria adjoining; then the Mineralogical Gallery (VII.), 500 feet; and the Gallery of Stratagraphical Geology (VIII.), 450 feet long, provides for the continuous survey of Nature from the mammal to the crystal, as required by the memorialists of 1858, and other naturalists. In front of this would stand the Rotunda, including on the ground-floor the theatre T, 76 feet in diameter. The galleries of Elementary Natural History and British Natural History are situated at E, E, and surround the circular building, to which light is admitted by side windows from the OPEN COURTS, C, C, C, C. The entrance-hall is at H, and at S are stairs leading to and from the upper floor, which contains the ethnological and geographical groups, arranged after the idea faintly indicated by the late Professor Edward Forbes at the Crystal Palace, in a domed rotunda, G, 150 feet in diameter, as required in Professor Owen's scheme, which also might contain, within the plane of the dome, as closely associated with geographical science, a large orrery, O, O, as in Fig. 6, which represents a section across A A. On each side of the rotunda are placed two blocks, the one on the right devoted to the reception-rooms and offices, D, of the director or superintendent, his secretary, etc.; and the private rooms, K, of the keepers of the zoological, botanical, mineralogical and geological departments; L, the lodge and apartments of the night guardian; and on the upper floor the library of general natural history, B. The left block is devoted to the lodge of the day guardian, L; refreshment rooms, R; guard-room and fireman's apartments, and watch-tower, F, F; and on the upper floor workshops, W, for purposes requiring the use of gas and fire; and M the mineralogical laboratory, lapidaries' room, etc. The lower rooms are lighted by side windows, the upper floors by angle lights. Covered ways for the protection of carriages on rainy days are provided between the wings of the two side buildings, indicated by the dotted lines between F and L and D and L (Fig. 3). Fig. 6, as we have remarked, represents a section across A A (Figs. 3 and 4).

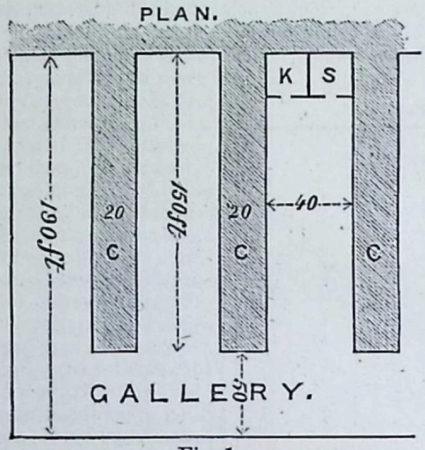
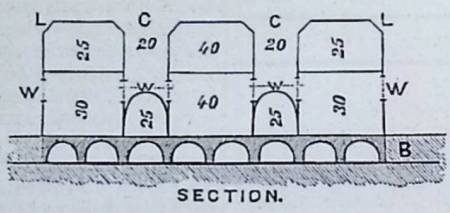


Fig. 1.



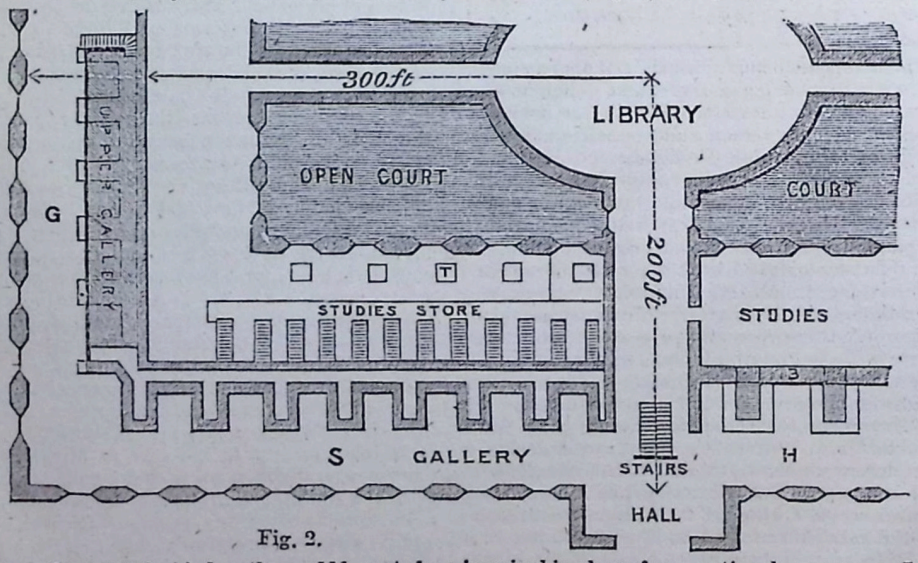


Fig. 2.

Provision against Fire.—At the present day houses for the keepers of certain departments are attached to the British Museum, but, as Professor Owen observes, "official residences, with servants, and especially with children, are elements of danger" to a national collection, he has not included space for such dwellings in his plans for a national museum. In connection with this observation, it may be stated that so greatly is risk from fire estimated by the present trustees of the British Museum, that though for years past Professor Maskelyne has urged the necessity for a small chemical laboratory, wherein the analysis of the minerals under his charge could be conducted, the trustees have uniformly declined to accede to that request, or allowed him, till within the last year or two, to temporarily rent, at small annual expense, an existing laboratory in the

* See "Committee on British Museum," Vol. XVI., 1860.

immediate neighbourhood, as one of their rules forbids a light or fire of any kind to be used within the walls of the museum, while another forbids any specimen to be removed from the building; so the keeper of the mineralogical collections has for many years been barred by the trustees from determining one of the most important characters of a mineral species or variety, though his scientific reputation was at stake on the matter of the correct naming of the specimens exhibited to the British public in their national museum.

The galleries of systematic natural history, as I have previously remarked, are planned for the perfect exclusion of artificial light and fire, provision being made for its being heated by hot-water systems, with isolated furnaces. The same rule would apply to the right-hand block, as containing the general library and the directors' and keepers' official documents, correspondence, official catalogues, etc. The left-hand block would be constructed with every provision against the extension of fire, should one occur, in laboratory, workshop, refreshment-rooms, or guardian's residences. The lecture theatre, the galleries of elementary natural history, of ethnology and geographical distribution, might be lighted by a gas system similar to that found to work so well in the South Kensington Museum. The supply-pipes should be arranged outside the building, with provision for instantaneously cutting off the supply by external main-taps. Gas properly arranged in a museum conduces to good ventilation, and causes less mischief than when there is less active ventilation, for on the gas being lighted at the South Kensington Museum on a hot summer's evening the temperature in the picture gallery has been decreased 2°, and the atmosphere of a crowded room at once materially improved.

In the Report of the Committee on Public Institutions previously cited, a curious result of some experiments on fugitive pigments is recorded. A series of sensitive tablets were prepared of uniform character, and distributed amongst certain public and private buildings. The most deteriorative effects were produced in the uninhabited National Gallery, the next worst place was an open country privy; the mischief at the former place being caused by the sulphuretted hydrogen emanating from the crowded visitors in a badly-ventilated gallery. The least effect was produced where perfect ventilation was attained by up-currents, caused by gas "sun-burners" placed in the roof of the building. The condensed gas lime-light apparatus, specially arranged for museum purposes, which has been described in this work in "Optical Instruments—Sources of Artificial light," may be advantageously and safely adopted in illuminating, as it presents the additional advantage of producing a light that exhibits *objects in their natural colours!*—a matter Dr. J. E. Gray considered unattainable by artificial illumination.

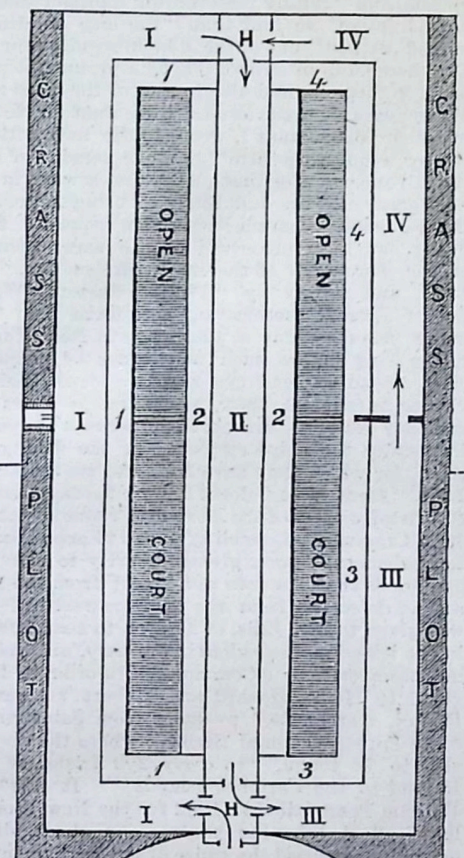


Fig. 3.

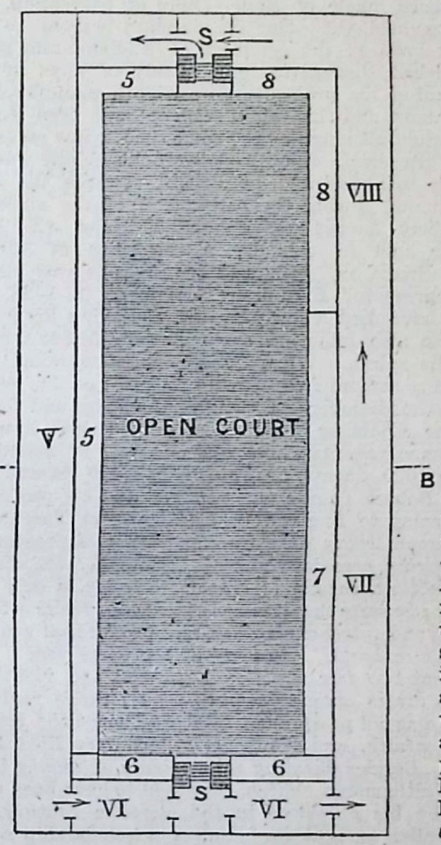
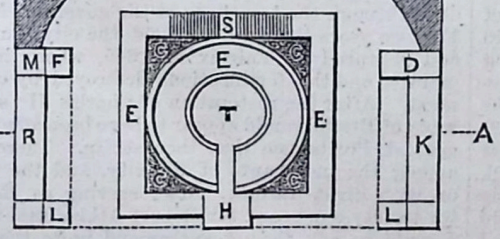


Fig. 4.



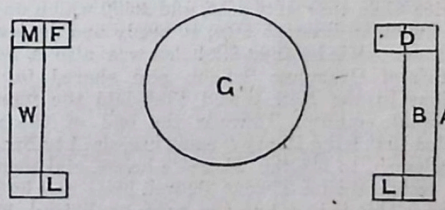


Fig. 6.

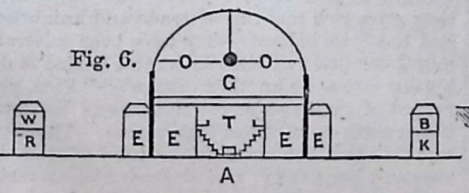
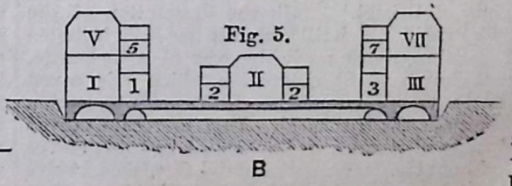


Fig. 5.



It will be noted that the rotunda and supplementary blocks are separated from each other, and this group isolated from the main building by a distance of 100 feet. Hydrants should be distributed around and within the buildings, not only for the purpose of providing against accident by fire, but also for keeping the external walls, courts, and surrounding grass-plots, pavement, etc., free from dust and smoke. The grass-plot, it is true, is not large in superficial area when compared with the great size and extent of the building, and its length makes it appear in the plan to be much narrower than it actually would be. It is, however, large enough for all practical purposes, and is, moreover, all that the space at command will allow, though the building itself would look better if it were larger.

SEATS OF INDUSTRY.—XXX.

BRISTOL (*continued*).

BY WILLIAM WATT WEBSTER.

AMONG the enterprising Bristol merchants who contributed to the fitting out of the expeditions of the Cabots, one of the most noteworthy was Robert Thorne, who claimed descent from Huldrich the Torn, uncle of Rollo, Duke of Normandy, and whose ancestors held the office of standard-bearers to the Norman house down to the conquest of England, and afterwards distinguished themselves in a variety of ways in this country. Several of his progenitors were cloth manufacturers and cloth merchants, and this would seem to have been Robert Thorne's chief trade, although at the same time he was an extensive dealer in white soap, which next to woollen cloth was the principal article manufactured in Bristol towards the close of the fifteenth and during the early part of the sixteenth centuries. Robert Thorne was appointed, along with fourteen others, to hold in commission the office of Admiral of England at Bristol in 1510, and in 1515 he was elected mayor. He represented Bristol in Parliament in 1523, and is supposed to have died a few years later, leaving his wealth to two sons, who also inherited much of their father's enterprise and public spirit. When Sebastian Cabot sailed with three ships and a caraval from Seville in 1526, on the voyage that resulted in the discovery of the river La Plata and the exploration of the adjoining districts, he carried with him the agents of various merchants whose ventures were estimated at a total of about 10,000 ducats, of which sum 1,400 ducats were contributed by Robert Thorne the younger and his partner in Seville. Returning to England in 1527, Robert Thorne the younger urged upon Henry VIII. the importance of prosecuting the work of discovery, especially towards the north, "the which," he argued in a letter to the king, "it seemeth to me, is only your charge and duty; because the situation of this your realm is thereunto the nearest and aptest of all other, and also for that you have already taken it in hand." In May of the same year "King Henry VIII. sent two fair ships well manned and victualled, having in them divers cunning men to seek strange regions," but the voyage was not prosperous. Robert Thorne the younger amassed great wealth, and his benefactions were liberal and wisely divided. Besides devoting a large sum of money to the rebuilding of Walthamstow church, supposed to have been originally erected by his ancestors in the eleventh century, and expending a smaller amount in founding a scholarship at the Merchant Taylors' school in London, this patriotic merchant bequeathed £300 for the purchase of a site for a grammar school at Bristol, £308 for the formation of a fund for buying corn and wood when they were cheap and selling them to the poor of Bristol at cost price when they were dear, and £500 which was to be lent in small amounts, interest free, to needy and deserving clothiers of the town. His brother Nicholas was also a benefactor of the Bristol Grammar School, and shared in the trading expeditions to the New World that laid the foundation of our colonial empire. Towards the end of the year 1534, it is recorded that King Henry "came disguised to Bristol, with certain gentlemen, to Master Thorne's house, and secretly viewed the city, which Master Thorne showed him; and he said to Master Thorne, 'This is now but the town of Bristol, but I will make it the city of Bristol.'" On the dissolution of the monasteries in 1540, Bristol, which till that date had been included in the diocese of Salisbury, was made the seat of a bishopric, and the conventual church of St. Augustine, which was saved from the Iconoclasts through Nicholas Thorne's intercession with the king, was made the cathedral. This merchant served Bristol in the capacity of member of Parliament in 1537, and as mayor in 1545. About the latter date Bristol furnished twelve ships for the war with France in which Henry VIII. was then engaged, the three largest vessels being the *Thorne* and the *Pratt*, each of 600 tons burden, and the *Gournay* of 400 tons, so called after the merchants at whose cost they had been built. The inscription on the magnificent tomb erected to the memory of Nicholas Thorne in St. Werburgh's describes him as "a famous and upright merchant, whose words were governed by truth, and whose deeds were ruled by justice and by virtue, whom the whole community of Bristol acknowledged as a munificent father; for by his bounty they were blessed."

During the reign of "Bloody Mary" three Protestant martyrs were burned at the stake at Bristol. Four ships were dispatched from the port in 1588 to join the fleet that was sent to oppose the Spanish Armada, and in 1574 Queen Elizabeth visited the city. When Sir Humphrey Gilbert asked the queen in the latter year to sanction an expedition of discovery and trade to the northern parts of America, "of all unfrequented places the only most fittest and most commodious for us to intermeddle withal," as he said, and "fatally reserved for England and for the honour of her Majesty," we find that "the city of Bristol very readily offered £1,000" out of the £4,000 required for the undertaking. The merchants of Bristol played a prominent part in the settlement of Virginia, and also in that of the more northern colonies. Three years after the issue of the patent for New England, which is dated 1620, James I. wrote to the authorities of Bristol and Exeter, requesting them "to move persons of quality to join in the advancement of that plantation, a work in which the public take great interest and likely to bring in good returns;" and Bristol readily complied with the request. Documentary evidence has been preserved of the early connection of many of the merchants of the city with America. A petition dated 1638, and signed by "Walter Barrett, Walter Sandy and Co. of Bristol, merchants," sets forth that "they have been many years settling a plantation in New England which was begun long before such multitudes of people went over; all they intend to send are regular people, neither factious nor vicious in religion; their plantation is apart from all others, and they desire to transport 180 persons; to provide victuals for furnishing the ships employed in the fishing trade upon that coast, for which they have built and made ready two ships." In 1651, "Lieutenant-Colonel Robert Yeomans and other merchants of Bristol, owners of the *Mary and Francis*," obtained permission from Cromwell's Council of State to accompany the fleet going to Barbadoes, "upon giving security to the value of the ship and goods that she does not depart from the fleet or trade with any in defection from the Commonwealth;" and in 1657 leave was given to Mr. Ellis, of Bristol, to send 1,000 dozens of shoes to the island of Barbadoes in January, and another 1,000 dozens in December. By a Commonwealth order of 1652, "liberty was given to Henry Hazard and Robert Yeomans, of the city of Bristol, merchants," to quote from Sainsbury's "Calendar of State Papers, Colonial Series," where the above particulars are also to be found, "to carry 200 Irishmen from any port in Ireland to the Caribbee islands!" It was from Bristol that William Penn sailed in 1682 for the New World. Being peculiarly affected in the controversy about ship-money, Bristol naturally espoused the cause of the Parliament in the Civil War, and was garrisoned by a body of the popular troops. It was besieged by Prince Rupert in 1643, and surrendered within three days through the treachery of the governor, Nathaniel Fiennes. For two years the royalists held the city, but it was assaulted and captured by Fairfax in 1645, when the castle was dismantled and the fortifications destroyed by order of the Parliament. After the restoration of Charles II., some of the inhabitants of Bristol would appear to have been affected by the reaction against Puritanism that then set in. There were two parties among the merchants of the city, and the strife was carried on with great warmth. After serving as Recorder of Bristol for twenty-one years, Sir Robert Atkins said in 1682, "I did all I could to join them together and unite them; for ever since they grew rich and full of trade and knighthood—too much sail and too little ballast—they have been miserably divided." The moral condition of the city at this period is described in the following terms by another citizen:—"Vice, profligacy, and a disregard of civil and moral obligations had entered the city and taken possession of her high places. The sacred fount of justice was polluted, her laws violated, and religion herself, in her holiness and her purity, was degraded to an instrument of cruelty, oppression, and wrong. In their abundance the people had forgotten the God they had acknowledged in their extremity. In their elevation, pride and the lust of power had supplanted the meekness and humility with which they were clothed in their adversity. They cared not to traffic with the bodies and souls of men, so that they supported their state and maintained their rule." The latter sentence of this heavy indictment refers to the share that Bristol merchants had in the African slave-trade, which was first added to the list of English trades by Sir John Hawkins, one of the famous Devonshire sailors of Queen Elizabeth's time, although it had been carried on upon an extensive scale by

the Spaniards and the Portuguese for more than a century previous to that date. Bristol was greatly enriched by its participation in the slave-trade, and continued to prosecute it with ardour till the suppression of the iniquity in 1807. Between the years 1795 and 1804, Bristol merchants shipped a total of 10,718 negroes from Africa to America and the West Indies.

Among the merchants who flourished in Bristol in the end of the seventeenth century, the most famous was Edward Colston, the last of a family that had been connected with the city since the year 1400, and several of whose members had filled important offices. It is chiefly as a philanthropist that Edward Colston is remembered. The first forty-five years of Colston's life was spent in London, but after the death of his father, which took place in 1681, he settled in Bristol, and carried on the business he had inherited, which consisted principally in sending ships to the West Indies with English goods, and bringing home sugar and other commodities. In 1689 he and his partners, Richard Beacham of London, Sir Thomas Day, and a Captain Nathaniel Wade, who had in his youth gone to New Jersey to form an ideal colony, and more recently had been implicated in Monmouth's rebellion, set up a sugar refinery at an old house known as the Mint, and in that year Colston took up his abode in the quaint house at Mortlake, still standing as a ruin, where Oliver Cromwell had lived before him. The benefactions of this merchant are too numerous to record. Every year he went through Whitechapel prison and the Marshalsea to empty his purse in freeing the most deserving debtors incarcerated for small sums, and in one case he sent £3,000 to liberate the poor debtors in Ludgate prison. He gave £20,000 to relieve the starving poor of the city of London in 1709, a year of famine, and in the following year he was returned as member of Parliament for Bristol, although he protested that he was too old to discharge the duties of that position, being then in his seventy-fourth year. Edward Colston's charities were so numerous and so munificent that they roused the jealousy of his brother citizens. In 1702, when he proposed to increase the number of Queen Elizabeth's Hospitallers from 50 to 100, the Bristol aldermen at first refused the gift, and denounced the institution as "a nursery for beggars and sloths, and rather a burden than a benefit to the place where they were bestowed," a criticism, however, that may not have been altogether devoid of truth. In 1707, Colston founded an hospital with school attached to it, in which about 100 boys are educated, maintained for seven years, and then apprenticed. He died at Mortlake in 1721, at the age of eighty-five.

When Queen Anne visited Bristol in the beginning of the eighteenth century, the splendour and cordiality of the reception she received made so great an impression on her that she said, "I never knew I was a queen till I went to Bristol." The charter of the city was confirmed by this sovereign. It was from Bristol that Dampier sailed on the voyage in which he fell in with Alexander Selkirk, the prototype of De Foe's "Robinson Crusoe." The history of the city throughout the eighteenth century is marked by few prominent incidents; but we may state that in 1761 Bristol contained nearly 100,000 inhabitants, and in 1799 there were twenty sugar refineries in the town, and no less than seventy full-sized vessels belonging to the port were engaged in the West India trade, sugar and negroes being then the staple articles of Bristol commerce. Serious bread riots took place in Bristol in 1753, and other disturbances broke out in connection with an agitation for the abolition of the bridge-toll in 1792. The most notable of the merchants of Bristol at that time were William Miles and his son Philip. In his interesting and elaborate work on "English Merchants," Mr. H. R. Fox Bourne gives the following account of the early history of William Miles:—"Somewhere near the year 1760—so the story goes—William Miles walked into Bristol with three-halfpence in his pocket, and a resolution to use his ready wit and his strong arms in advancing his then very slender fortunes. Taking the first porter's job he could meet with in the streets, he earned sixpence thereby. With fourpence he managed to buy food enough for the day, and to find some sort of lodging for the night. Next day he earned more, and earning each day more than he spent, he worked on as a street porter till he had saved a sum of £15. With that he apprenticed himself for three years to a carpenter and joiner, and during those three years he earned some more money and gained some further experience by doing evening work for a small ship-builder in the neighbourhood. He thus qualified himself, when his apprenticeship was over, for going out as a ship's carpenter in a Jamaica merchantman. While in Jamaica he applied his little savings in buying a cask or two of sugar, for which he was allowed free passage to Bristol, and while there he managed to sell at a considerable profit. With the proceeds he procured a little stock of such articles as he thought there was the best market for in Jamaica. So he went on, from each voyage earning more money, and enabling himself to carry on a larger traffic. Thus he came to be known on both sides of the Atlantic as a man of remarkable energy and honesty, and as soon as he had capital enough he settled down as a merchant in Bristol with certainty of success. So well did he succeed that in 1795, when his son Philip John, then twenty-one years of age, proposed to marry a daughter of the Dean of Lismore, he was rich enough to hand him a cheque for £100,000, and so, it was said, to remove the opposition of the aristocratic clergyman to association with the family of a self-made man." The son was a partner in his father's business, and carried it on after his father's death in 1805. Although he lived in princely style and spent his money freely, Philip Miles left personal property, at his death in 1848, valued at upwards of a million sterling. Conrad Finzel, a native of Frankfort, was an eminent Bristol merchant contemporary with the younger Miles, whose career was even more remarkable than that of the elder Miles. Flying from his native country to escape the conscription, Conrad made his way to London, where he found employment in a sugar refinery, and soon rose to be second boiler in the establishment, and which he left to become principal refiner in a sugar-house at Bristol. By 1836 he had earned and saved enough money to enable him to join with a partner in the working of a small refinery in Counterslip, on the site of which now stands the largest sugar refinery in the world, built in 1846 at a cost of £250,000, which yields 1,000 tons per week, and gives constant employment to more than fifty large West Indiamen. This establishment belongs to Messrs. Finzel, Son, and Co. Besides the profits of his own works, Conrad Finzel, during the latter years of his life, derived an income of about £10,000 a year from royalties paid to him by other refiners for the use of the vacuum pan and centrifugal vat for making crystals, which he had invented and patented. This merchant prince bestowed his means lavishly on charities of all sorts, and especially on the Orphan House established at Ashley Hill by his countryman, the Rev. George Müller, his gifts to which amounted during several years to £10,000 per annum. He persistently refused to accept any public function; and when elected as an alderman without his consent, he replied to the urgent entreaty of some of his fellow-citizens to serve the city in that capacity—"God gave me a faculty to be a good sugar-boiler, but no turn or talent to be a town-councillor." Conrad Finzel died at Wiesbaden in 1859, while on a visit to his native land.

PRINCIPLES OF DESIGN.—XXXI.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

STAINED GLASS.

In the Earthenware or Majolica Gallery of the South Kensington Museum a number of windows have been placed bearing subjects illustrative of the potter's art in various times, which are drawn in black on a plain light glass. Some of these are excellent, and most of them are well worth seeing.

Nearly twenty years since, when a comparatively young student at art, I was struck with the beauty of the frost on the window-pane such as we commonly see in winter on the glass of our sleeping-room windows, and was led to make sketches of some of the more beautiful forms. Ten years later I founded a style of window decoration on these sketches, and to this day I regard some of the patterns which I produced from these sketches as consistent and desirable enrichments for stained glass, and as my favourite works. Of these designs one was engraved (Fig. 143) in my last article. If this pane of glass be formed of a pale amber sheet of rich cathedral glass with the pattern drawn boldly in black, it will be such as I think satisfactory. Instead of the whole being formed of one piece of glass, the various parts may be differently tinted, and the whole leaded together, if colour is desired.

In the present chapter I engrave another design of a somewhat similar character, but consisting chiefly of curved parts (Fig. 146). Of the two I prefer the former and more simple treat-

ment, but when considered together, the two may give rise to a new style in domestic window glass.

In the last chapter I also gave an illustration of a bordering (Fig. 144), such as might be placed round a plain sheet of plate glass: this border would give colour and decorative effect, and its treatment I regard as correct. It is often desirable to form a window of small parts, or quarries, and if these are well managed very effective windows may be produced. These quarries may be enriched with conventionally treated plants, where the entire plant may be of one colour, and the background of another (old quarries are often met with bearing a flower, or a bird, or an animal, simply and conventionally drawn in outline on a pale green-grey glass, and having the figure filled with a yellow tint), or the flowers may be separated from the foliage by a third tint. Fig. 147 is an adaptation of the fuchsia, and Fig. 148 of the corn cockle (*Githago*), and in this last instance the leaves are arranged into the figure of the fleur-de-luce. Fig. 149 is only of floral character, but is not founded on any particular plant. Fig. 150 is after the type of the lotus bud. Fig. 151 is less floral in character, but retains a little of the vegetable type, while Figs. 152, 153, and 154 are wholly conventional in character.

Although I have occupied my space chiefly with illustrations, I may be excused for adding a few more remarks on art in glass painting, proceeding by saying, that if a window is placed in a very sunny situation, where it is intended to act in part as a blind, the introduction of a considerable amount of black, as in Figs. 147 and 149, is sometimes desirable, and certainly gives great force to the pattern.

To return for a while to Fig. 143, we have already remarked that the strong black lines of the pattern would look very effective when drawn on a pale amber-tinted sheet of cathedral glass. The effect of this may be ascertained approximately by drawing the design on a thin piece of lemon-coloured paper, and holding it up to the light, or even fixing it to a pane of glass. It must be remembered, however, that it will be impossible by this simple contrivance to gain anything more than an approximate idea of the actual appearance of the pattern when drawn on glass of the tint suggested, as the glass affords a transparent medium, while the paper is opaque, or partially so. The design may be applied in a variety of ways. It is suitable for a long, narrow, lancet-headed light, in which the pattern may be repeated thrice or four times, as shown in the figure; the pointed pane at the top of the light being filled with the lower part of the design, which is confined by two curved lines springing from either side of the base, and meeting in a point a little above the actual centre of the drawing, as it is figured in the diagram. If the light be broad enough, the three or four sheets thus treated may be surrounded by a narrow border, in which, on a black ground, might be depicted amber leaves springing from a continuous stem running up the centre of the border, and turned alternately in opposite directions. Such a border would be in harmony with the central part of the window, the tints used for pattern and ground in the one being simply reversed in the other; but if it be preferred, there is no objection to the use of deeper and richer colour in the border, though, if this were done, the colour used should present a satisfactory contrast to the tint on which the pattern is delineated, as without strict attention to this, the effect produced will be far from pleasing to the eye. The same design may be used in sheets of glass placed side by side, as, for example, in the four window-panes frequently used to form the centre of a glazed door, and surrounded by panes of less width.

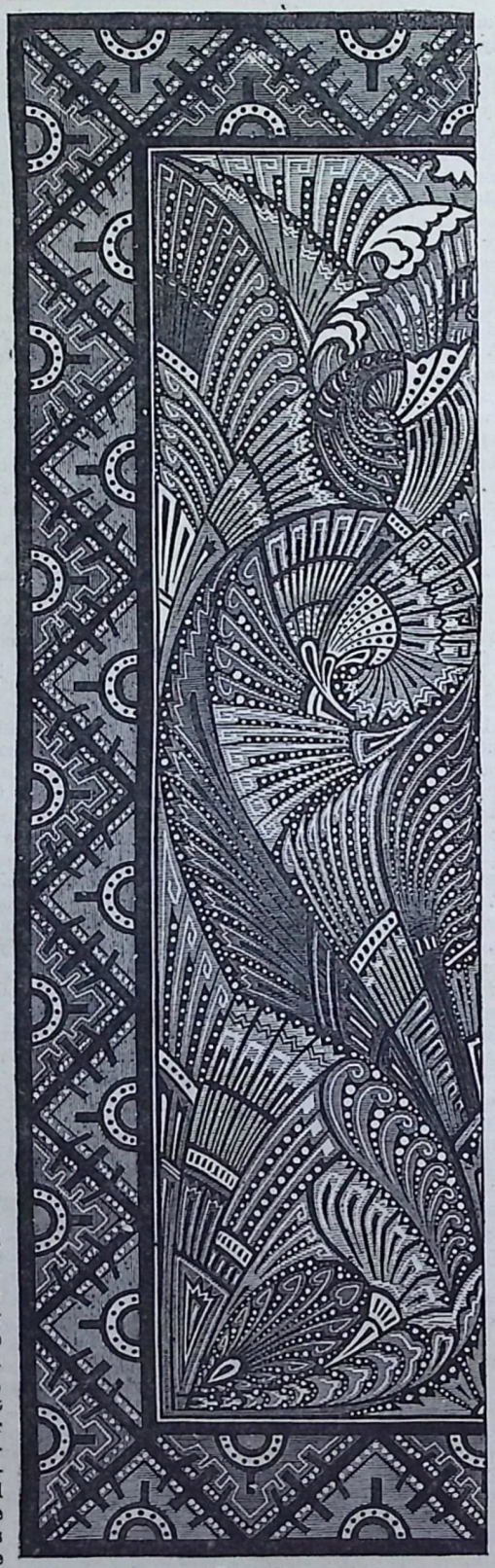


Fig. 146.

The border shown in Fig. 144 is adapted for the enrichment of a window, of which the centre is comparatively plain and simple in design, and devoid of much colour, as in the window shown in Fig. 145. Such a border presents a rich and beautiful effect when painted in three different tints of the same colour, the portion that is perfectly black in the design being painted in the darkest of the three tints—a tint, in short, approaching very nearly to black, or being the darkest possible shade of the colour used; while that which is white in the figure should be of a very light tint of the colour, and the part that is shaded of a tint forming as nearly as possible a mean between the darkest and lightest tint used. Another satisfactory mode of treating the design would be to allow the parts shown in black and white in the figure to be black and white in the painted copy as well, and to colour the shaded portions in any single tint forming a mean between black and white, that would be in harmony or pleasing contrast with the colours of the centre round which the border is disposed. The same mode of treatment will apply in an equal degree to the colouring of the figures given with the present chapter, and we may point out here, what may have already occurred to many of our readers, that a beautiful window may be formed out of Fig. 146 simply by repeating the design and border, so as to form a symmetrical pattern on either side of the central line, which, in case of a duplication of the design in this way, would be the line that now forms the boundary of the pattern on the right.

In forming designs for quarries, or small diamond-formed pieces of glass, similar to those shown in the opposite page, it is useful to search for plant-forms either common or peculiar to the neighbourhood in which the work is intended to be placed. In every district something worthy of conventional treatment may be found, and it is as right and necessary to use such forms for decorative art, whether in colour or carving, as it is wise in building to avail oneself of the building materials that the district yields.

Fig. 152.

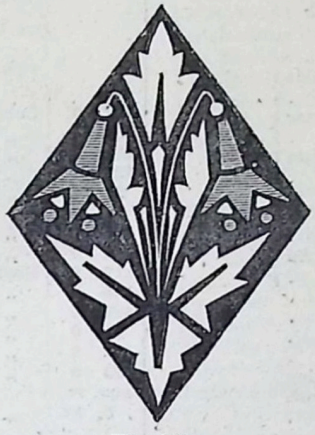


Fig. 147.

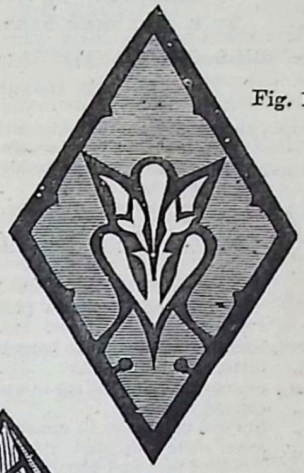


Fig. 151.

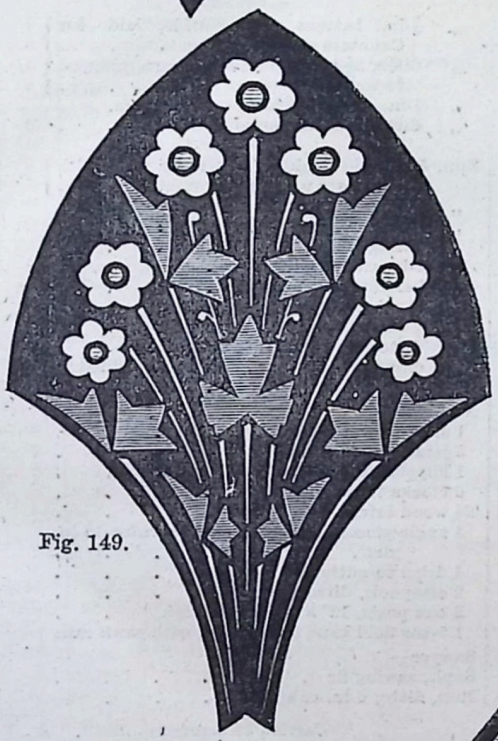


Fig. 149.

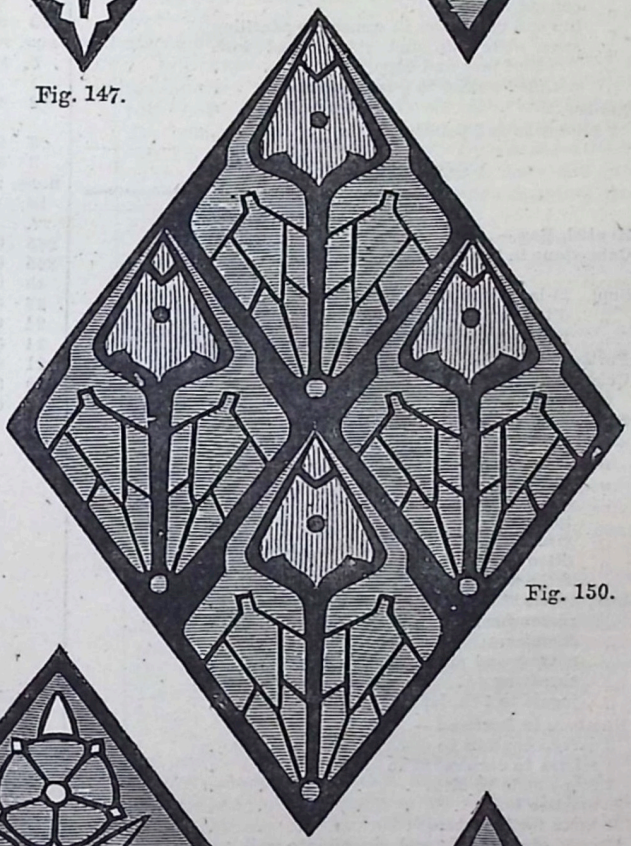


Fig. 150.

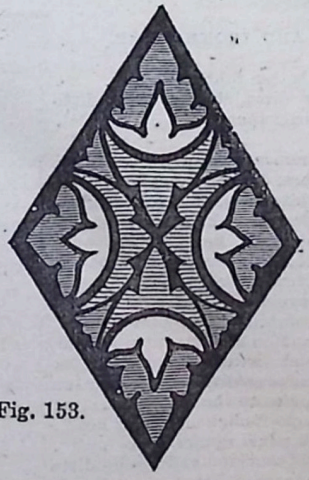


Fig. 153.

Fig. 148.

Fig. 154.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVIII.

BY E. WYNDHAM TARN, M.A.

BILL OF QUANTITIES (*continued*).

TILER AND SLATER.

SQR.	FT.	
10⅓		Supl., plain-tiling, showing 4 in. on face, double fir laths and wrought nails
8½		„ pantiling, 10 in. gauge, bedded in mortar and pointed
9	44	„ Countess slating, 2½ in. lap, each slate with 2 1½-in. copper nails
9¼		„ asphalted felt, laid under slating
FT.	IN.	
30	0	„ ¾-in. sawn slate shelf, planed
61	9	„ flat roof of 2 courses plain tiles in cement
28	0	Run, heading plain tiling to bargeboard
28	0	„ ditto, pantiling, ditto
31	6	„ ornamental ridge tiling in cement
28	0	„ cement filleting
45	0	„ hip and ridge tiles in cement to pantiling
45	0	„ sawn slate hip and ridge, fixed with white lead and copper screws
24	0	„ rounded nosing to ¾-in. slate shelf

Number—
2 hip-hooks and painting 3 oils

Carried to summary . . £

MASON.

FT.		
		Kentish Rag—
187	6	Cube stone in bondstones
YDS.		
132		Supl., 24-in. rough random walling
131¼		„ ditto coursed ditto
274		„ pointing in blue ash mortar
FT.		Portland Stone—
757	8	Cube stone rough
8	4	„ ditto landings
46	6	Supl., 3-in. balcony
93	7	„ sawing
614	10	„ plain bed
710	5	„ plain work
133	5	„ sunk ditto
371	11	„ moulded ditto
13	1	„ circular ditto
75	5	„ ditto sunk ditto
11	10	„ ditto moulded ditto
39	0	Run, lintels 9″ × 9″, in 6 ft. 6 in. lengths
17	10	„ groove for lead
83	3	„ chamfer
7	6	„ cutting and pinning to landing
96	8	„ throating
6	0	„ joggle to 3-in. landing

Numbers in Portland—
2 carved capitals to design
4 mitres to cornice, 27 in. girt
2 stopt ends to ditto
20 mortise holes
30 holes for balusters
17 ends of steps, cut and pinned into wall
28 plugs
30 slate dowells
24 lbs. lead for running plugs

YDS.		
		Yorkshire stone—
12¾		Supl., 2½-in. tooled paving
FT.		
58	6	„ 3-in. templates and core for cornice
31	6	„ ditto rubbed hearths
11	3	„ 7-in. sink
26	0	Run, sill 9″ × 3″, weathered and throated
51	0	„ coping, 12″ × 3″, ditto
43	0	„ cutting to edge of 2½-in. paving

Numbers in York—
12 fair ends to sills
2 ditto coping
1 rounded corner to 7-in. sink
1 rebated hole ditto

YDS.		
		Pavior—
41¾		Supl., Elland edge pitching in sand and grouted
FT.		
30	0	Run, granite curb, 12″ × 6″

		Marble—
21	0	Supl., 2-in. polished slab
15	2	„ 1-in. ditto

Number—
4 console chimney-pieces, value 10 gs., P. C.

Carried to summary . . £

CARPENTER.

FT.		
36	0	Cube, fir, use and waste in shoring
32	8	„ ditto, bond, plates, etc.
138	3	„ ditto in single joists
135	3	„ ditto, framed in trusses
56	4	„ ditto, girders, sawn down, reversed and bolted
4	7	„ ditto, proper doorcase
0	9	„ oak, weathered sill
113	9	Supl., centering to vaults and arches
135	0	„ bracketing to cornice
481	6	„ planing fir
60	0	„ 1-in. deal gutter-board and bearers
27	6	„ ditto, feather-edged louvre boarding
23	5	„ 1½-in. ridge piece
SQR.	FT.	
5	88	„ ¾-in. battens, 3½-in. wide, laid for Countess slates
2	41	„ ditto, 2¼-in. ditto, 10-in. apart, plugged to wall
3	60	„ 1-in. sound-boarding on two fillets
3	61	„ ditto, weather-boarding
RODS.	FT.	
16	0	Run, 5 feet cleft oak pales, 2 arris rails, with oak posts 9 feet apart
FT.		
265	0	„ 1-in. oak plank, 12-in. wide, to fence
265	0	„ ditto, capping, ditto
49	0	„ tilting fillet
24	6	„ 2-in. ridge roll
24	0	„ herring-bone strutting
14	0	„ turning pieces 4½ ins. wide
21	6	„ ¾-in. deal arris gutter, 4 in. deep
10	3	„ ditto water-trunk, 4½ in. square
12	6	„ circular head to window frame, glued in thicknesses, 5″ × 3″

Numbers—
1 shoe to water-trunk
2 joints, ditto
1 hopper-head, ditto
6 blocks to purlins
24 wood bricks
4 angle-pieces to bracketing of cornice 18 in. girt
4 drips to gutter
2 cesspools, ditto
2 oak posts, 12″ × 12″, 5 feet high
1 5-bar field gate, 9 feet wide, with sawn rails

SQR.	FT.	
		Sawyer—
1	96	Supl., sawing fir
0	240	Run, ditto, 6 in. oak rails

Carried to summary . . £

JOINER AND IRONMONGER.

SQR.	FT.	
2	17	Supl., 2 cut white batten folding floor
1	87	„ 1¼ in. yellow ditto, straight joint, ditto
1	96	„ ditto, with iron tongues
FT.		
15	9	„ deal-cased frames, oak sunk sills, 1½ in. ovolo sashes, double hung with brass pulleys, white lines, and iron weights
22	0	„ deal-cased frame, oak sunk and weathered sill, 2 in. deal lamb's-tongue sash, double hung, brass pulleys, patent lines, and iron weights
29	3	„ ditto, 2 in. ovolo sash, ditto
35	9	„ solid oak rebated and moulded frame, 4″ × 3″, mullion and transom, mitred, beaded, and weathered sill, 2 in. lamb's-tongue casement, circular on plan, ¼-in. rise to the foot
7	0	„ 2 in. oak ovolo fanlight, circular head
16	6	„ 1¼ in. deal 2 panel square door
16	6	„ ditto, 4 panel moulded and square ditto
17	11	„ 1½ in. ditto, square ditto
42	3	„ 2 in. ditto, moulded both sides, ditto

26	3	,,	2¼ in. oak 6 panel bolection, moulded ditto, lower panels bead flush
35	9	,,	1¼ in. deal 2 panel bead flush, and square shutters, hung with brass pulleys, patent lines, and lead weights
15	2	,,	ditto, moulded and bead flush, folding ditto
13	0	,,	ditto, bead flush and square back-flaps
10	3	,,	ditto, proper boxings
105	4	,,	deal revolving shutter, with worm and wheel gearing
66	0	,,	1¼ in. yellow deal treads, and 1 in. risers, glued and blocked to close-string, moulded nosing and two fir carriages
19	3	,,	ditto, ditto, winders
69	11	,,	1¼ in. yellow deal treads, 1 in. risers, mitred to cut-string, glued and blocked, with moulded nosings, and 2 fir carriages
17	11	,,	ditto, winders
13	9	,,	ditto, rebated and beaded outer string, cut and mitred to risers
1	6	,,	ditto, writhe
11	11	,,	ditto, close-string
35	0	,,	ditto, wall ditto
19	0	,,	ditto ramp
21	11	,,	¾-in. deal, wrought 1 side and framed
2	3	,,	ditto, and beaded
8	0	,,	ditto, rebated and beaded
7	6	,,	ditto, both sides, and dovetailed
14	0	,,	ditto, tongued
31	8	,,	inch deal, wrought 1 side and tongued.
66	1	,,	ditto, and rebated
29	9	,,	ditto, square skirting
30	5	,,	ditto, torus ditto
7	11	,,	ditto, 1 side framed, moulded in 1 panel
21	9	,,	ditto, keyed frieze, joints feather-tongued, rebated for soffit
26	8	,,	ditto, wrought both sides
3	0	,,	ditto, framed and beaded
8	3	,,	1¼ in. wrought 1 side, framed, moulded in 2 panels
9	7	,,	ditto, 1 panel
26	4	,,	ditto, both sides
42	3	,,	ditto, framed and beaded
7	6	,,	ditto, cut and diminished
19	0	,,	ditto, moulded and square framing
5	0	,,	ditto, ditto, circular on plan (½-in. rise to the foot)
22	9	,,	ditto, spandril
53	9	,,	ditto, moulded and rebated skirting, in two heights
12	10	,,	1½ in. deal, wrought 1 side, double rebated and beaded
21	11	,,	ditto, framed and moulded
18	2	,,	2 in. deal clamped dresser top
43	6	,,	cradling to entablature, ploughed and tongued blockings
24	0	,,	moulded cornice
7	0	Run,	½-in deal, wrought stop
7	8	,,	¾-in. ditto chamfered fillet, 2¼ in. wide
40	6	,,	ditto, skirting grounds, plugged
7	9	,,	ditto bead
43	0	,,	square angle-staff, plugged
9	6	,,	deal drawer runners
34	0	,,	groove
48	9	,,	ditto, and tongue
10	6	,,	1 in. nosing.
52	7	,,	ditto, skirting grounds, plugged
25	0	,,	ditto, picture grounds, ditto
4	6	,,	ditto, double beaded pinrail, 4½ in. wide
75	0	,,	ditto, architrave moulding, 2¼ in. ditto
60	6	,,	ditto, ditto, 3½ in. ditto
76	6	,,	1½ in. ditto, ditto
6	6	,,	ditto, ditto, circular
20	0	,,	ditto, mitred border
9	6	,,	moulding, 4 inches girt
2	6	,,	ditto, ditto, circular
12	0	,,	2¼ in. deal wrought and framed legs
15	6	,,	ditto, turned newells
13	0	,,	ditto, moulded handrail

We are compelled by want of space to terminate our ideal "Bill of Quantities" for joiner and ironmongery here at the conclusion of the articles which are measured by foot-run. On resuming the subject in our next lesson, we shall commence with such of the joiner's work as is taken by number.

TECHNICAL DRAWING.—LXXV.

DRAWING FOR BRICKLAYERS (*continued*).

THE example (Fig. 599) forming the subject of the present lesson is the ground-floor plan of a small villa built of malms, with stone dressings. The plan is drawn to the scale of ⅛-inch to the foot, the exterior walls being a brick and a half thick, whilst the interior ones are one brick thick.

On entering the house, we have first the hall, on the right-hand side of which is the dining-room, and on the left the drawing-room.

As the villa stands alone, or as it is termed "detached," these rooms which are at the corners have two windows each, by which means different views of the surrounding country are obtained, and the cheerful aspects are increased.

The front window in the drawing-room is a "bay" 7′ 6″ wide, and 3′ 3″ deep. This feature adds to the size of the room; makes a very pleasant recess, and is a great improvement to the elevation of the villa.

The side window may be made to open like a pair of folding-doors into a conservatory or garden; these are called "French casements."

On the same side of the hall, and immediately at the back of the drawing-room, is another smaller room, the library or study; this is also lighted by a window overlooking the garden, and thus the room is light, airy, and cheerful; but still it is from its situation removed from interruption. By placing a door where marked in the wall, access may be obtained from the drawing-room to the library, which being opened when occasion may require, will give increased accommodation.

Passing along the entrance-hall under the landing, we have a water-closet on the left, and a door leading to a little back lobby, on the other side of which is the back door leading to the kitchen garden or drying ground.

On the right-hand side of this lobby is the kitchen, beyond which is the scullery, and on the left side is the pantry and store-room.

It will be evident that when the door at A is closed, all communication between the kitchen and scullery, and the dining-room, library, and drawing-room is effectually cut off, thus preventing the annoyance, so often experienced in houses of this class, of the odour arising either from kitchen or scullery spreading into the other apartments. This door should be made self-closing by means of a spring, and could, of course, be hooked back when required.

By this disposition of the front and back doors a thorough current of fresh air passes from one side of the house to the other. They should therefore be opened together at certain periods every day, and if the windows of the rooms be opened at the same time, the whole mass of air in them will be purified. This does not apply to the ground floor only, but to the whole house.

Many persons are under the impression that a house is properly and efficiently cleansed by sweeping and dusting. There cannot be a greater mistake. Very much of the dust so disturbed rises and floats in the air, which is further vitiated by the breathing of the inhabitants, gas, etc. It is absolutely necessary not only that the floors and stairs, but the *whole atmosphere* of a house should be swept; and therefore, in the morning especially, the doors below should be opened, and the fresh air allowed to pass completely through the house, the bedroom doors and skylight having been previously opened. The impure air will thus be changed, and the comfort, cheerfulness, and health of all in the house will be improved accordingly.

The scullery or washhouse is placed adjoining to the kitchen, but may, of course, be separated from it by closing the door. The external door of the scullery opens directly on to the yard or drying-ground.

The pantry, which has already been mentioned, is for convenience placed opposite to the kitchen, so as to be as far as possible removed from the influence of the continuous fires. The floor is tiled, and slate and wooden shelves are affixed to the walls. Especial attention should be paid to the ventilation of the pantry. There should be an aperture at the bottom of the door covered with perforated zinc, and the upper panes of the windows should be replaced by pierced glass, or some other form of ventilation.

A door from the pantry leads to the store-room. The floor of

this room is boarded, and it is furnished with commodious cupboards. A small fireplace is also provided to prevent damp, and for the occasional airing of the room. A small aperture in the bottom of the door, covered with perforated zinc, will, together with the open chimney, keep the room ventilated, and more air may, of course, be obtained by opening the window. In the basement are coal, beer, and wine cellars, and other domestic offices, which would be shown in the basement plan.

This plan should be drawn on the lower part of the sheet of paper, so that the elevation may be projected from it. Great care must be taken in working accurately to the scale, and in preserving the rectangular forms of the rooms. This is best done by using the set-square against the T-square, as already explained.

Fig. 600 is the front elevation of the villa. The general widths of the various parts will be obtained by projection from the plan, whilst the heights and details are to be obtained from the examples. It is not usual in elevations to delineate the separate bricks, a few lines being merely drawn to indicate the character of the material of which the house is built. The same remark applies to the slates of the roof. All architectural drawings should be inked and coloured.

For colouring elevations, crimson lake mixed with burnt sienna or Venetian red gives a nice tone of colour for *red* brickwork; very pale yellow ochre is generally used for malms; and the same, or pale sepia, for stonework used for the dressings. Granite is represented by pale Indian ink, and red sandstone by light red.

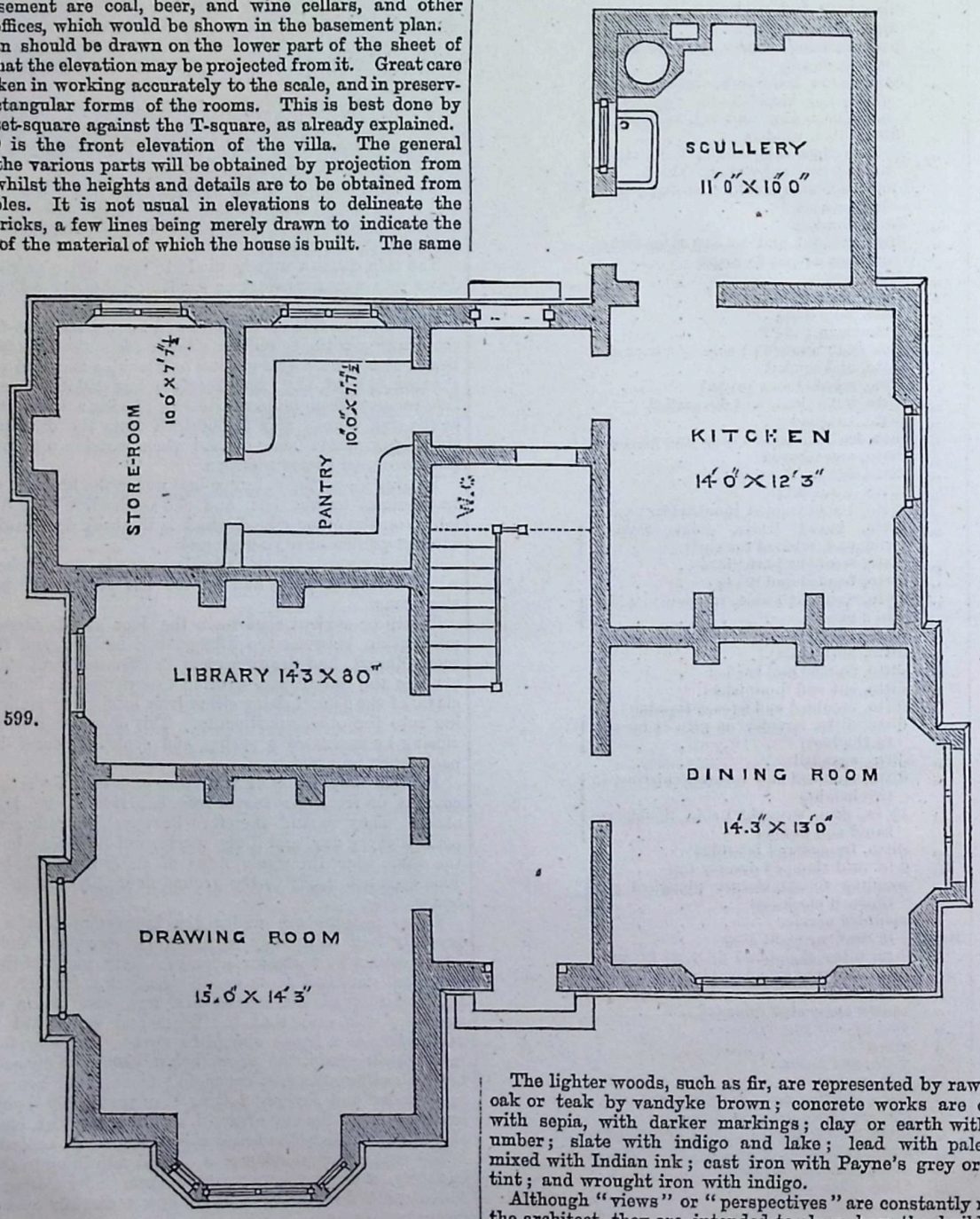


Fig. 599.

TO COLOUR ARCHITECTURAL DRAWINGS.

Assuming that the plan and elevation have been carefully inked, the next process is that of colouring them.

The plan of the walls, representing brickwork, is generally coloured with lake; but many draughtsmen prefer a full black, which really shows the exact forms to great advantage, especially in large drawings intended for exhibition.

The lighter woods, such as fir, are represented by raw sienna; oak or teak by vandyke brown; concrete works are coloured with sepia, with darker markings; clay or earth with burnt umber; slate with indigo and lake; lead with pale indigo mixed with Indian ink; cast iron with Payne's grey or neutral tint; and wrought iron with indigo.

Although "views" or "perspectives" are constantly made by the architect, they are intended to show how the building will look when finished; but they are not in any way concerned in the construction. The drawings to which we have alluded are those required, and our instructions as to colouring will therefore in the present instance be limited to flat tinting, not by any means extending to "drawings in water-colours."

This must not be construed into any desire on our part to check the laudable ambition of the student; we merely wish to advise him to limit his efforts at first to that which is absolutely necessary; and this foundation once laid, a superstructure of the noblest character may with safety be raised on it.

We wish to impress on the student that no amount of shading or colouring, however well done, will improve a bad drawing; whilst a good outline will mostly represent the object without either one or the other; and therefore, although the learner is advised to spread flat tints over his earliest drawings so as to represent material only, by this means carrying on a course of improvement in both branches simultaneously, he is warned against spending time on making highly-finished picture views until he has mastered the principles of architectural construction, of architectural drawing and flat colouring, and until he shall have acquired such a knowledge of perspective as may ensure the correctness of the outline.

The colour for laying a flat tint must be very thin; it is very easy to spread another wash over it when dry, if not found dark enough, but if too dark it is not so easily lightened; in fact, this is seldom satisfactorily accomplished.

In mixing two colours, so as to produce a third, as in the case of lake and burnt sienna mentioned above, rub the colours in separate compartments of the slab, or at different parts of the palette, leaving a space between them, in which the colours are to be mixed with the brush. Never rub one cake in any other colour previously mixed; by this plan the end of the cake becomes stained, and consequently the purity of the colour afterwards rubbed from it will be impaired.

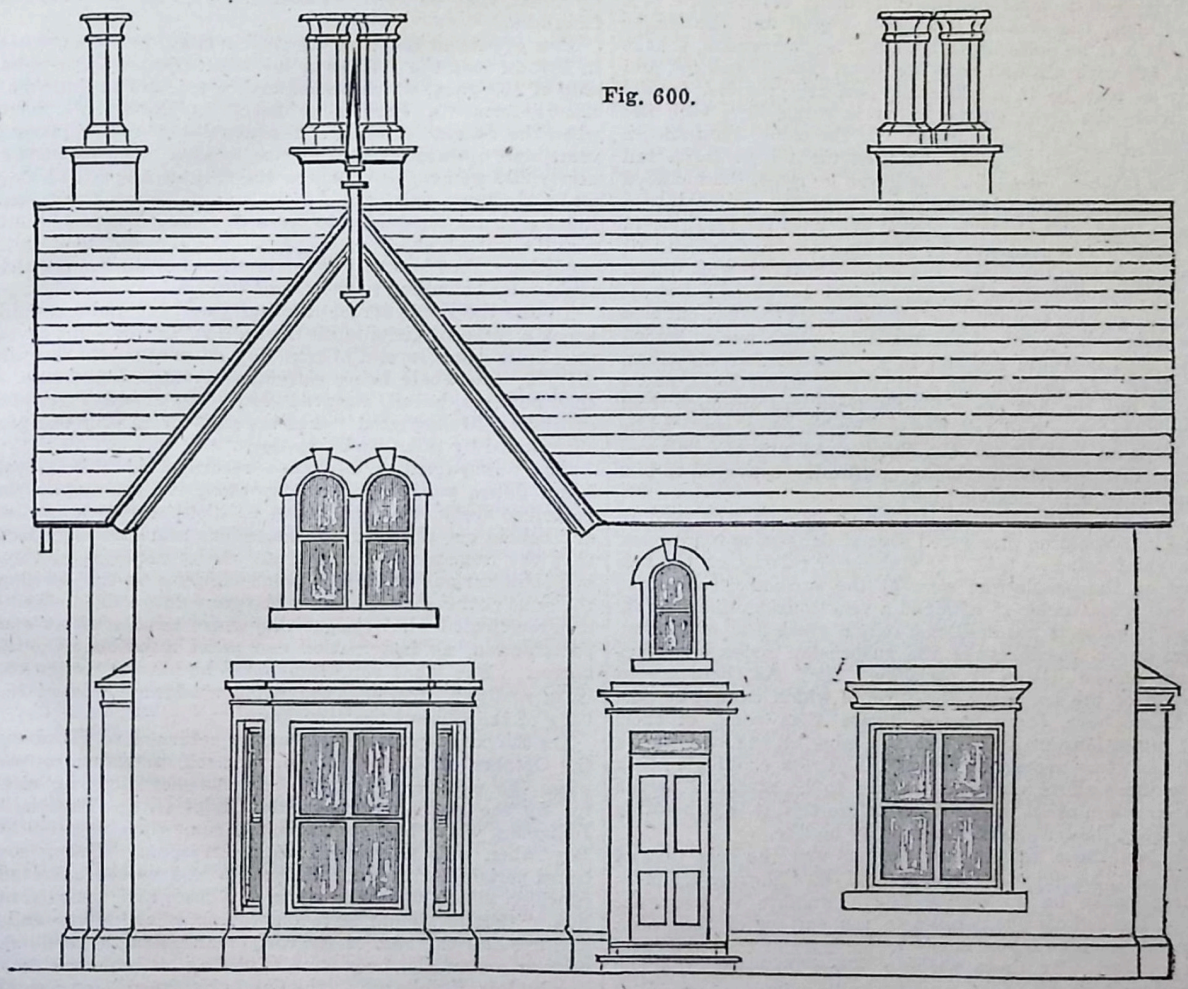
Use a large brush in preference to a small one wherever possible, especially in laying flat tints, which are liable to become streaky when coloured with a small brush.

The whole surface which is to receive a flat wash should be covered as rapidly as possible, but care must be taken that the brush does not pass over the outlines. Should this, however, occur, it is best to take up the colour covering the whole surface with blotting-paper, and allow the paper to dry; then repeat the outline, and colour as before, but with more care; the part at which the outline had been overstepped will then be visible, but of course not so dark as the rest. Now moisten this with a brush containing colour, and allow it to soak in for a moment, then take up the water from the surface with blotting-paper. Cover the part of the drawing which has been correctly coloured with a strip of paper, holding it tightly against the outline; rub the part coloured accidentally with a piece of clean india-rubber, and by this means it will in most cases be removed. If possible avoid scraping with a penknife or eraser, as the paper thus becomes roughened, and catches the dust more easily than if the above method has been pursued.

After the colour has been spread it should not be touched again whilst wet. If it should require any retouching, let this be done when it has dried; it will generally be made worse by any attempt to remedy it by stirring about in the wet colour, and, further, the surface of the paper will become roughened.

In order to obtain the necessary practice in laying flat washes, which is of great importance in architectural drawing, the student is advised to draw several squares, circles, rectangles, triangles, etc., of different sizes; to commence by colouring the smallest, and gradually proceeding to those of increased size. The brush should be held as upright as possible, so that the point and not the side may be used.

Fig. 600.



BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIV.—CHARLES SPALDING.

BY JAMES GRANT.

This ill-fated inventor of many improvements on the old diving-bell was born at Edinburgh, about the year 1735. He commenced life as a shop-lad; his parents were in humble circum-

stances; but being steady, thrifty, and industrious, he ultimately succeeded in establishing himself in an extensive business as a confectioner and sugar-refiner. All his leisure hours were turned to the study of mechanics, and among many other things to which he gave his attention was the diving-bell, which no man in Britain had ever attempted to use, since the days of Dr. Halley.

Spalding being a man of a brave and intrepid spirit, and inspired also by a keen curiosity to inspect the wonders of nature, made several attempts to descend into deep water with the bell, and ultimately succeeded, so that he could remain under the surface for a considerable time. This led him to consider attentively the general construction of the bell, and seek to render it more useful and safe.

The diving-bell is most conveniently made in the form of a truncated cone, the smaller end being closed and the larger opened. It is to be poised with lead, and so suspended, that it may sink full with air, and with its open face downward, and as nearly as may be in a situation perfectly parallel to the horizon, while the diver, sitting under it, sinks down with the included air to the depth required. If the cavity contained a ton of water, it would hold air sufficient for a man, for a full hour, at six fathoms deep; but the lower he went, the included air contracted, according to the pressure of the water, into a compass so small, as to become heated and unfit for respiration, so that there was a necessity for it being drawn, to recruit it, and then generally the diver was almost covered with water. To obviate these difficulties, Dr. Halley had contrived an apparatus which not only recruited the air from time to time, but also kept the water wholly out of the machine, which was so loaded with lead, that it would descend in a perpendicular direction, but no other. In the top was a window to admit light, and a cock to let out the hot air, while the fresh was supplied from two barrels that rose and fell like two buckets in a well; while by an additional contrivance, the diver could quit the bell and walk some distance, the air being constantly conveyed to him in a machine by small flexible pipes.

Such was the diving-bell as left by Dr. Halley, who died in 1741, and in it Spalding discovered several dangerous tendencies, the two chief being:—1st. The sinking or raising of the bell depended on the people who were at the surface of the water, as the bell when under it attained a very considerable weight, and thus to raise it required not only a great deal of labour, but there was a possibility of the suspension ropes breaking, and every person within it perishing. 2nd. As there are in many parts of the sea rocks, the form of which cannot be perceived from above, there was a chance that some of their ragged projections might arrest the edge of the bell in its descent, and thus overset it, before the divers could give any signal to those above, an event certain to be attended by the total destruction of all within it, as before trial it is impossible to know what the bottom of the sea may be like.

To obviate these defects and dangers was the first task of Spalding, and this object he attained in the following manner:—On iron hooks he suspended leaden weights to keep the mouth of the bell *always* parallel to the surface of the water, whether the machine taken is lighter or heavier than an equal bulk of water. By these weights alone, however, the bell would not sink, so he added another to be raised or lowered at pleasure, by a rope passing over a pulley and fastened to the sides. This he called "the balance weight," as it hung considerably below the mouth of the bell. It served also as an anchor, to keep the bell at any particular depth which the divers may deem necessary, or by pulling it quite up the descent may be continued to the bottom. By another ingenious contrivance, too long for description here, Spalding rendered it possible for the divers below to be independent of those above, and to raise the bell with all its weights to the surface, or to stop its descent at any depth they chose. For the wooden seats used by Dr. Halley, he substituted ropes, suspended by hooks, with two side windows of strong glass for the admission of light, and he maintained that one air-barrel, capable of containing thirty gallons, was sufficient for an ordinary machine. Steele, Rowe, and James have made considerable improvements since, even on Spalding's bell, but such was the nature of the machine in which he made several descents, and which, towards the close of the last century, attracted the attention finally of the government.

He became so proficient as a diver that he could remain in his bell for several hours at the depth of fourteen fathoms, and the *Edinburgh Advertiser*, for 1783, records that a lady and a gentleman named Watson went down with him in Leith Roads, "and remained at the bottom of the sea for half an hour."

A ship from London, bound for Leith, on board of which Spalding had much goods consigned to him, having been cast away, he made a proposal to the owners of the general cargo, "that if they would bear a share in the general expenses of his journey to where the wreck lay, he would make every effort in his power for the recovery of their joint property." On their declining, Spalding at his own risk visited the wreck, and though he recovered little or nothing of his own consignment, being chiefly sugar and other perishable commodities, he brought up much that belonged to others, which no law could wrest from him.

Few events at the time created a more profound sensation in Britain than the sinking of the *Royal George*, a line-of-battle-ship of 108 guns, which turned over when undergoing what the sailors term "a Parliament heel," in Portsmouth harbour, when the venerable Admiral Kempenfeldt (then in his seventieth year), and upwards of 400 officers, seamen, and marines, with nearly 200 women, perished, on the 29th of August, 1782. Immediately upon this, the Admiralty and Navy Boards sent to Edinburgh for Spalding, to have the wreck inspected, and, if possible, raised wholly or in part. He engaged to do this on condition "that he was to have one-third of all the property he could raise belonging to the *Royal George*."

To this the Lords of the Admiralty agreed, and he paid the wreck a series of visits in his diving-bell, and brought up seventeen brass guns, several of iron, and other stores to the value of £1,000, the whole being estimated at thrice that sum. For this, however, he only received £400, half of which went for his expenses. He reported "that the ship lay in very bad ground, surrounded by tides, and very deep."

The newspapers of the time record, that "Mr. Spalding being down, one very clear day alongside the *Royal George*, perceived every object on board as distinctly as above water, and beheld one of the most tremendous and shocking spectacles that the human mind can form. Great numbers of the dead bodies in various attitudes; some clinging to the carriages of the guns; others crushed with the guns above them; and when it is recollected what visages they must have in that state of putrefaction, no imagination can paint it without the utmost horror. But what sensations must he have felt when viewing it in reality! Through the cabin-windows he could see the body of the admiral floating about."

On the cold season setting in, he returned to Edinburgh in the October of 1782, pledging himself to resume operations when the weather permitted. In the meantime, he was sent for by the underwriters of the *Belgioso*, an Imperial East Indiaman, which had been wrecked some time before in Dublin Bay when outward bound from Liverpool. Every soul on board perished with her. Her cargo was valued at £150,000, of which £30,000 were in silver and lead, and their agreement was, "that he should have one-fourth of the silver and lead, and one-half the rest of the cargo; and though he should not recover an article, they were to defray his expenses from the day he left Edinburgh to the day he returned." As she lay in ten fathoms water, and six miles from the shore, not amid quicksands, with her masts visible at ebb, there was every prospect of his realising the liberal offers of the Liverpool underwriters prior to resuming his labours on the *Royal George*, the wreck of which he proposed to blow up, as has since been done, by gunpowder. At this time he was also in correspondence with Commodore Elliot, the Governor of Gibraltar, who wished him to raise 400 brass cannon, that were sunk in the Bay by the Spaniards when they abandoned the siege of that fortress on the famous 13th of September, 1782.

In May, 1783, he was at Dublin, and anchored his small brig in the Bay, with his diving-bell on board. On this occasion he was accompanied by a friend, Mr. Ebenezer Watson, also of Edinburgh, and together they paid four visits of inspection to the wreck of the great Indiaman, which lay near a place called the Kishes.

The fourth visit was paid by them on the 3rd of June, when the water was seven fathoms deep, and they were below it exactly an hour and a quarter. During the first hour the signals had

been properly attended to, and three supplies of fresh air were sent down; but it is supposed that unhappily, by some blunder in those above, the last barrel failed to reach them, and thus brought on almost instant suffocation. It must have been so immediate as to have prevented Spalding from adopting the mode of preservation invented by himself—viz., that of cutting away the weight that hung from the centre of the bell, by which means it must have instantly risen to the surface.

On drawing up the bell, Spalding and his young friend Watson were both found dead, the former resting on the breast of the latter, who was sitting erect in the slung seat. No medical man being at hand, when the brig ran into Dublin harbour all attempts at recovery were futile. At the inquest, the captain asserted that the signal ropes must have become entangled below water. By this catastrophe Spalding's widow and seven children were left in penury, and Watson's aged mother. The event made some sensation in Dublin, where Spalding and Watson were interred together in the churchyard of St. Mark. They were borne shoulder-high by the crew of his brig, and were preceded by the marine boys singing hymns. Many of the most influential citizens attended the funeral, and all the vessels in the harbour and bay had their flags half-hoisted as a tribute to Spalding's memory.

SHIP-BUILDING.—XVI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE DECKS OF SHIPS.

DECKS were originally constructed in ships solely for purposes of convenience and accommodation; now they are recognised not only as valuable platforms, but also as important contributories to the structural strength. In some of the earlier papers attention was directed to this fact, and the usefulness of decks in assisting to prevent changes of form in either the longitudinal or the transverse direction was illustrated. Consequently it is unnecessary here to discuss the subject further; but taking for granted the importance attaching to the proper construction of decks, and their connection with the other parts of the structure, we will attempt to show how in practice these special requirements are met. As in other cases, our treatment must necessarily be brief, and only the principal features of the various arrangements can be described.

The surface of a deck is curved both longitudinally and transversely. The longitudinal curvature is termed "sheer," and the transverse curvature "round up." The latter is mainly given in order to facilitate the flow of water to the sides of the ship, where "scuppers" are formed to permit it to pass overboard. Sheer is given to the decks mainly for the sake of graceful appearance in the upper boundary lines of gunwales and topsides; the foremost and aftermost ends of the deck being usually higher than the amidship part. It is very commonly supposed that a loss of strength is caused by giving sheer to the decks instead of having them straight; but this is not true, provided the decks are so strongly connected with the sides of the ship, as to prevent any change in their relative positions; and there is no practical difficulty in securing the strength required for the purpose. Some ship-builders have even gone so far as to give the decks longitudinal curvature in the reverse sense from that usually given, thinking that the *arched* form thus obtained would be most valuable in resisting hogging strains; but in doing so they have overlooked the facts, that sagging as well as hogging strains have to be resisted, that change in the longitudinal form of the ship must affect the sides as well as the decks, and that the great aim of the builder should be to secure joint action and mutual support between the sides and decks.

Structurally considered, decks may be said to consist of the "flat" and the "framing." Under the former heading may be included the planking forming the platform upon which the various fittings are constructed, and the different weights directly rest, together with any iron plating that may be fitted beneath the planking. As framing may be reckoned those pieces which support the flat, just as the frames support the skin of a ship, these pieces are named beams, half-beams, carlings, etc., and closely associated with them are other pieces named "shelfs" and "waterways." The support of the decks does not wholly depend upon the strength of their framing, but is largely aided by pillars fitted between decks and in the hold. In building a ship the decks are first framed, and the flats are laid afterwards; so that the most natural course is to give precedence to the framing in the following remarks.

In nearly all ships the deck-framing is placed transversely. A few iron ships have been constructed by Mr. Taylorson with diagonal deck-framing, associated with other diagonal arrangements; and others built on Mr. Scott Russell's longitudinal system have had their decks supported by longitudinal girders; but these exceptional cases are so few as to merit no detailed description. The almost universal rule is to place the transverse deck-beams at moderate distances apart, and to make them stretch from side to side, strongly connecting their ends with the framing and skin of the ship. The spacing of the beams depends largely upon the positions of the hatchways and other openings in the decks, in wake of which the beams cannot, of course, be continuous from side to side; at such places short transverse pieces or half-beams are fitted instead. The outer ends of these half-beams are secured to the ship's side, and their inner ends rest upon longitudinal pieces of the deck-framing, termed "carlings," fitted between the beams. In some cases half-beams are fitted at other parts of decks, so that the spacing of the beams may be increased and the weight of the deck-framing reduced; but this practice is almost entirely confined to wood ships. These three classes of pieces—beams, half-beams, and carlings—form the deck-framing in most modern ships, whether wood, iron, or composite; and although in older wood vessels other modes of framing were employed, we cannot here attempt to describe them.

The beams of most wood ships consist of solid timbers of nearly uniform depth and of rectangular cross section (see 3, Fig. 5, Vol. III., p. 29). They commonly have to be made up in length by two or three pieces, which are joined by scarfs, either plain or hooked (see Fig. 8, Vol. III., p. 30). Their spacing, from centre to centre, varies from 3 to 4 or 4½ feet when there are no half-beams; and when half-beams are fitted in order to lighten the deck-framing without leaving the flat unsupported, the spacing is sometimes made as much as 5 or 6 feet. In determining the actual positions of the beams regard is had, as was said above, mainly to the positions of hatchways; but other considerations connected with deck fittings, special weights requiring support, possibility of fitting pillars, etc. etc., also have great influence. Half-beams and carlings are of similar sectional forms to the beams, but usually of less dimensions. Iron beams are sometimes used in wood ships, and in the next paper an example of such an arrangement will be given.

Wood beams were commonly used in the earlier iron ships, but they soon gave place to iron. The advantages of the flanged form possible with iron beams, as regards strength and lightness, have already been illustrated; and in 1 and 2, Fig. 5, two sectional forms for iron beams are shown. Section 1 has not been much used, and could not be rolled in one piece until quite recently; but we believe beams of considerable size on this pattern can now be rolled. The old plan of making it was to roll half the web and either the upper or lower flanges in one T-shaped piece, afterwards welding the two parts (at the bottom of the T) throughout the length of the beam. Section 2 is known as a "made" beam, and it has been largely employed. Besides these, many other sectional forms have been used, some of which will be illustrated hereafter. One of the simplest is the simple angle-iron form, but this is deficient in having only an upper and no lower flange. To supply this want a "reversed" angle-iron has sometimes been riveted to the simple angle-iron beam, and so a section like that of the frame of an iron ship (see Fig. 20, Vol. III., p. 150) has been obtained. Another plan has been to roll the angle-iron with a bulb at the lower part of the flange placed vertically; T-iron beams have also been used. Besides these we will only mention here the so-called "box-beams," sometimes used where great strength is required. They are of rectangular section, the sides, top, and bottom consisting of comparatively thin plates connected together by angle-irons fitted at the corners of the rectangular section. These beams are nothing less than small tubular girders, and they can be almost as readily made as the T-shaped beams similar to 2 in Fig. 5, Vol. III., page 29.

We have already remarked that in an iron beam there is no necessity for such elaborate connections of the pieces as there is in a wood beam. Usually the manufacturer sends the beams to

the iron ship-builder in such a state, that their ends have only to be cut off to the exact length, and the necessary holes drilled or punched, before the beams are put in place. In cases where made-beams are used the builder has to prepare them himself, but the operation is very simple. The plates forming the web may, in a large ship, be in two or three lengths, which are joined by welding; and a similar operation suffices to procure the necessary lengths of the angle-irons. Care is taken to make the welds of the plates and angle-irons forming a beam give shift to one another, in order that any specially weak section may be avoided; and in many cases, in disposing these butts, regard is had also to the positions of the similar butts on neighbouring beams. Much interest attaches to many of the operations connected with the manufacture of iron beams, but space forbids us to enlarge thereon further than in connection with some of the more common methods of forming the "knees."

Figs. 52 and 53 will aid our description of these operations, and also enable us to complete our remarks on the sectional forms of beams. In the former sketch the beam is made up of a bulb-plate with double angle-irons on the upper edge; this is a very common sectional form in iron and composite merchant ships, and is both cheap and efficient. The bulb-plate is rolled in one piece, and afterwards combined with the angle-irons. The section in Fig. 53 is generally known as the "Butterley beam," having been first made by the Butterley Iron Company. It was formerly always made in two pieces, which were afterwards welded together (by a patented process) along a line near the centre of the depth or the "neutral axis" of the beam. Now beams of considerable size and of similar sectional form can be rolled in one, and the expense and labour of welding saved; but the welding process is, we believe, still necessary with the largest beams, such as are used in our iron-clad ships. The advantages gained in having finished beams turned out from the rolls, instead of having to combine the separate parts, are too obvious to need discussion; and there is every probability that the iron manufacturers will be able eventually to meet the ship-builder's requirements in this respect.

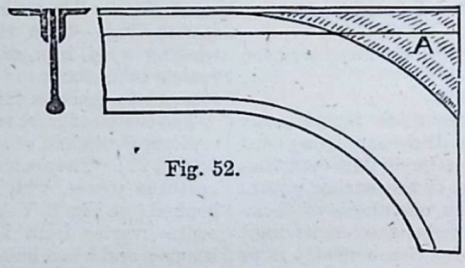


Fig. 52.

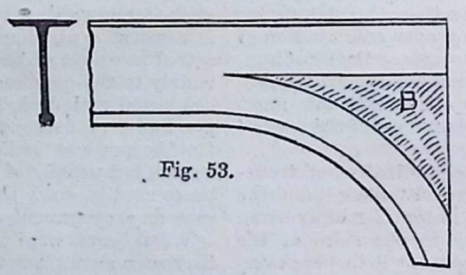


Fig. 53.

From these two sketches the outline of the form usually given to iron beam-knees will be seen, and hereafter the advantages gained thereby will be understood. The extreme depth of the knee is usually not less than 2½ times the depth of the beam away from the knee. In Fig. 52 the desired form of knee is obtained by making the beam-end hot (before the angle-irons are riveted to the upper edge), and then bending the bulb-plate to the curve required for the under part of the knee; after which the piece of plate marked A, and dotted across, is welded on to form the upper corner. In Fig. 53 the plan followed is different. If the beam is formed of two pieces welded along the neutral axis, the welding is not performed for some two feet or so from the end; or if the beam is rolled in one piece the web is cut or split for an equal length, in order to separate the upper and lower parts. The beam-end is then heated, and the lower part turned down to the required curve to form the beam-knee; after which a plate marked B, and dotted across, is welded in to fill the space and complete the beam-arm. Sometimes the plate B does not entirely fill the space, but a triangular hole is left at the inner part. An example of this will be given hereafter. Care is, of course, required in welding plates (such as A and B) to the beam-web; and the operation takes some time, but when complete it makes very neat work.

I-shaped "made" beams usually have knees of similar shape to those we have just described, the web-plate being increased in depth for the purpose at the beam-end, and the angle-irons on the lower edge being bent to the curve of the lower edge of the knee. One of the best methods of forming such knees is to cut them out of a solid plate of sufficient breadth to allow two knees to be formed, and then by properly "lining" them out on the plate no great waste of material is involved. The knees, or "beam-arms" so formed, would extend in for 4 or 5 feet from the ship's side, and there be welded to the web-plate. It may occur to the reader that a plan similar to that in Fig. 52 might be applied here also, and this is the case when the beams are not of considerable depth; but as made-beams are mostly used where great strength is needed, there would be considerable difficulty in bending the deep web-plates to the curve required, and it is not usually attempted. Sometimes, to avoid the cost of cutting out the plate-knees, pieces of plate are either welded or riveted to the lower edge of the web-plate, in order to give the desired depth and form; and sometimes, instead of forming knees at all, the beams are continued of uniform depth quite out to the ship's side, and other means are adopted for securing their ends.

Half-beams in iron ships are usually of the same form and dimensions as beams, and have similar knees on their outer ends. The inner ends are simply secured to longitudinal carlings by short pieces of angle-iron, and the carlings themselves are similarly attached to the beams between which they are fitted. It is not usual to fit half-beams except in cases where some necessary arrangement of hatchways or deck-fittings prevents the beams from being made continuous from side to side. Almost without exception, the beams and half-beams are stationed at frames in iron ships, and their spacing consequently depends greatly upon the frame-space. In ordinary iron ships on most of the decks the beams occur at alternate frames, and are from 3½ to 4 feet apart. In iron-clad ships the deck-beams are ordinarily spaced 4 feet apart; but in some cases where it has been desired to make the deck exceptionally strong, and very thick plating has been fitted, the beams have been only 2 feet apart. Such cases, however, must be regarded rather as having relation to necessities of defence, than of structural strength in the ordinary sense. The decks, in fact, are nothing less than targets strongly plated, and requiring to be strongly framed in order that the plating may be made as efficient as possible against the oblique or vertical impact of heavy projectiles.

Deck-beams are required to act not only as supports to the decks, but also as struts and ties keeping the two sides of the ship at a fixed distance apart, and to assist the framing in resisting any alteration in the form of transverse sections. The sectional forms of iron beams are practically regulated by the consideration of the strains brought upon them when acting simply as girders supporting the decks and the weights placed thereon. And when it is remembered that their strength as struts against compressive strains is very largely increased by their connection with the deck-flat, it will appear that this practical rule rests on a sound foundation. It is obviously fair to consider that with each beam we may associate, as a strong top flange, a portion of the deck-flat on each side of it extending to the middle of the beam-space. Supposing this to be true, and assuming the beam to be subjected to compressive strains tending to make it buckle, we see how great is the assistance it receives from the deck-flat to which it is fastened; and these are the strains to which a slight iron beam is most liable to yield when unstiffened. Direct tensile strains it can resist much better, and to enable its strength to be thoroughly developed it is only necessary to rivet it strongly to the frames. With wood beams there is no choice of any sectional form except the rectangular; and there is, of course, practically no danger of such beams failing under compressive strains, while the care exercised in scarfing the various pieces secures their efficient action as ties against tensile strains, provided their ends be securely fastened to the ship's sides.

Experience proves, however, that the greatest danger of change in transverse form arises from those strains which tend to produce alterations in the angle between the beam-end and the ship's side. The causes and mode of action of such strains have already been described; and in the next paper we shall try to illustrate the means employed to resist their action.

PATENTS AND PATENT LAW.—I.

By A Barrister.

UNPATENTED INVENTIONS.

In commencing the treatment of this interesting subject we must caution the reader that if he desires to make our information permanently useful he must carefully watch the proceedings of Parliament, as changes affecting the practice at least relating to patents are imminent. There is indeed a difference of opinion as to the advisability of preserving any monopoly, many persons whose judgment is entitled to weight being in favour of absolute free trade in ideas. At present the law rests upon a statute of James I., to which we shall presently allude—a statute which abolished monopolies generally, but expressly retained that which confers protection upon inventors whose discoveries relate to manufactures. That the law has remained for so long the same in principle is much in its favour; and it is indisputable that if our existing system be judiciously amended, the advantage to art and science will be as great as the original abuses of monopolies were enormous.

The most material question which we have to consider in the first place is the position of an individual who conceives a novelty in relation to matters covered by the term "manufactures," and who does not at once proceed to patent it. Has he any protection at all at common law, that is, as distinguished from statute law? M. Renouard, the author of an elaborate French work on patents, discusses the question whether an inventor has, by the principles of universal equity, an exclusive right to his invention; and an eminent American writer, Mr. Phillips, says that M. Renouard "very satisfactorily establishes the conclusion to which every mind is constrained to yield assent, that no such natural right exists." "Indeed," says the writer last cited, "there is no plausible ground whatever on which to rest such a right, since the fact of one person being the first inventor or discoverer affords no pretence for disfranchising others of the right, in their turn, of making use of the discovery." The only condition upon which an inventor can keep his invention to himself is that of secresy. It is the same with regard to literary productions as with mechanical inventions. The great American Chancellor, Kent, observes, "As long as these are kept within the possession of the author, he has the same right to the exclusive enjoyment of them as of any other species of personal property; for they have proprietary marks, and are distinguishable property. But when they are circulated abroad, and published with the author's consent, they become common property, and subject to the free use of the community." After many decisions of the courts, Lord Cottenham recognised as the established doctrine, that the property of an author or composer of any work, whether of literature, art, or science, in such work, unpublished and kept for his use and pleasure, cannot be disputed. And he added that if such right and property exist in the author of such works, it must so exist exclusively of all other persons. Upon this arises a very nice question as to what acts of an author or inventor will deprive him of his right—a question which has been frequently discussed on many different states of facts. And this is most important to inventors, inasmuch as by an indiscretion they may lose their right to a patent.

An instance of the danger of losing the benefit of his invention to which an inventor is liable is given in the work of Mr. Phillips already referred to. A person had invented an improvement upon spectacles, and as his patent was in a state of forwardness he had not been sufficiently cautious in keeping the invention to himself, so that another person in the same trade had acquired a knowledge of it, and hastily got a pair made upon the same construction, and exposed them in his window. Fortunately, however, the inventor happened to pass the shop, and seeing them, employed a friend to go and purchase them, in which he succeeded, and his patent passed the Great Seal the next day, before there was time to get any more made. It is difficult to see, however, that this patent could have been held good. There was knowledge of the secret, an actual making, and a public sale by a person who was not the patentee. All the world does not think alike on this subject of publication. France has adopted the English doctrine, but the United States law is satisfied if the invention was new at the time that it was made; and it is considered that the inventor is rather benefited by making known his invention as soon as he has reduced it to practice, because he supplies himself with proof of the date of the invention.

In the beginning of the present century a case was decided in the Court of Errors in France which well illustrates the rule which prevails in that country and in England. The inventors of a carding machine had disclosed their invention to the municipal administration of Orleans, who, at their request, had tested its utility by a public inspection and experiment, of which they had given a formal certificate to the inventors. The inventors, moreover, had voluntarily permitted a manufacturer to use their machine to card with. It was adjudged that in thus giving publicity to their invention they had voluntarily made it public property, and consequently, that the patent subsequently obtained by them, though in other respects legal, was invalid. The inventors protested that they did not intend to make their invention public, or to part with their rights, which we can well understand. But the only question in such a case must be, whether publicity has been given to the invention, from whatever cause; for it is the publicity which gives the public the right, and consequently deprives the inventors of their privilege.

It is desirable to fix with as much precision as possible the kind of proceeding on the part of an inventor which will prevent him from subsequently obtaining a patent. This was discussed in the great case of Betts' patent for metallic capsules, where it was said that a person named Dobbs had made the process public before the date of Betts' patent. Lord Chancellor Chelmsford considered carefully the "nature and extent of the information published to the world, which will be sufficient to disprove the novelty of a subsequent invention," that is to say, which (having regard to our present purpose) would disentitle an inventor to a patent at all. In one of the cases referred to, Lord Westbury answered the question thus: "There is not, I think, any other general answer that can be given to the question than this, that the information as to the alleged invention given by the prior publication must, for the purposes of practical utility, be equal to that given by the subsequent patent. If specific details are necessary for the practical working and real utility of the alleged invention, they must be found substantially in the prior publication." This was not entirely adopted by the Court of Queen's Bench dealing with the same patent; that court considering that whilst the earlier specification might insufficiently describe the process, so as to make the specification bad, it yet might disclose enough to show that what was claimed on the patentee's specification was not wholly new. And Lord Chelmsford expressed his entire concurrence with the view put forward by Mr. Justice Williams, "that the publication of a *notion* that a certain useful art may be discovered, without any information or means of discovery, cannot preclude a subsequent inventor of those means from taking out a patent for the entire art." A publication of a description of a machine in a book is enough to deprive the inventor of his property in it. "If," Lord Lyndhurst said in a case, "the machine is published in a book, distinctly and clearly described, corresponding with the description in the specification of the patent—though it has never been actually worked—is not that an answer to the patent?"

Then, in addition to publication, there is another process by which a new idea may be lost to its originator, and that is by public use. Mr. Justice Erle told a jury that manufacturing according to the subsequent patentee's invention, and sale "commercially" of the article so manufactured, would be a "public use." To support a public use a learned Vice-Chancellor required the evidence of "somebody who was an habitual purchaser." The same judge said "a manufacture of an unsaleable article will not be an anticipation of a patent which will produce a different, and a saleable, and a merchantable article." A doubt may well occur to the reader as to what is an unsaleable article. Lord Chelmsford supposes the words to mean a "worthless article;" "for," he said, "an article which is capable of some useful application may, from circumstances, be unsaleable at a particular time, and yet, if manufactured not for experiment, but in the way of trade, may prevent another patent having a claim to novelty." He further held that to establish a public use it is not even necessary that the patented article should have been previously manufactured for sale. As an example, a lock on a new principle was put on a gate adjoining a highway, and that was said to be a public use, so as to

defeat a subsequent patent. A late Baron of the Exchequer defined "public use" to mean "a use in public so as to come to the knowledge of others than the inventor, as contradistinguished from the use of it by himself in his chamber." Lord Abinger defined it thus: "the public use and exercise of an invention means a use of an invention *in* public, not *by* the public."

This reference to authoritative opinion on the subject we are dealing with makes it very clear, and it is only necessary to state what rules have been established as regards literary and artistic property, the law of copyright being distinctly on all-fours with the law of patents. These rules have been well summed up thus:—That the right of property of the author or composer of any works of literature, art, or science, in such works, so long as they remain unpublished, is so complete and absolute, that no one else, without his permission, may publish even a list or descriptive catalogue of them; that the circulation amongst a few private friends of impressions of etchings, not otherwise published, is not such a publication of them as disentitles the owner to the protection of this right, and that this right is but part of the general common law right of property. The question of publication is, of course, quite as important respecting this description of property as in the case of mechanical inventions; and in addition to the case of the etchings referred to above, we will give a few examples of what amounts to a publication so as to divest the author of his right of property. We may premise that the thing itself must be published, not something resembling it, such as an abridgment. A public performance of a play does not deprive the author of his common law right of property in it. By sending letters to another the right of publishing them is not lost; nor does the mere gift of copies of an author's works to a few friends amount to an abandonment of his copyright before publication. Unpublished lectures, delivered under certain conditions, musical and dramatic compositions, engravings, maps, and charts, are protected by statute.

We hope we have placed the position of an inventor at common law so clearly before the reader that any *résumé* may be unnecessary. But with reference to what we have to say further on, we will re-state the simple principle thus:—An inventor may retain the exclusive property in his invention without a patent, so long as he does not allow it to become publicly known by description in a publication or use in public. In the case of literary or artistic creations there may be a public use without amounting to a publication so as to deprive the author of his property in his work.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXV.—HENRY CORT.

BY JAMES GRANT.

HENRY CORT, the founder of our iron aristocracy, was born at Lancaster in the year 1740. His father was by trade a builder and brickmaker. Of the early history of Henry Cort nothing is accurately known, but (according to a notice of him which appeared in the *Mechanics' Magazine*) he would seem to have raised himself by his own unaided efforts to a position of respectability. In his twenty-fifth year he was established as a navy agent in Surrey Street, Strand; and it was while managing business in that capacity that he seems first to have become aware of the inferiority of British iron, as compared with that which came from Russia and Sweden. The English nation could not carry on their manufactures without the foreign ore; hence their wrought iron was prohibited from all Government contracts, and their cast iron was too brittle for general use.

A supply of iron being required for the Royal Navy, first drew Henry Cort's attention to this state of matters in the iron trade, and he began a series of experiments with a view of improving the manufacture of the metal. What these experiments were, or how he achieved the results that he did, no one knows now. All that is known is that in the year 1775 he quitted his offices in Surrey Street, and took on lease certain premises at Fontley, near the seaport of Fareham, in Southampton, where he built a forge and iron-mill; and then he took into partnership a Mr. Samuel Jellicoe (son of the deputy-paymaster of seamens' wages), a measure that proved in the end a most unlucky one.

Henry Cort took up the art of manufacturing iron at the point where it had been left off by Dr. Roebuck in 1762, the Brothers Cranage in 1766, and others; and he succeeded so far with his new experiments at Fontley, that in 1783 and 1784 he published his patents. In his process he dispensed with a blast; but in that he had been anticipated by the Cranages, and in puddling by Peter Onions of the Merthyr Tydvil Works. Yet he introduced so many improvements of a new and original character, combined with the inventions of some of his predecessors, that in a few years he raised the iron manufacture to the highest state of prosperity—so true it was with Cort that "the man who will distance his competitors is he who masters his business, who preserves his integrity, who lives clearly and purely, who devotes his leisure to the acquisition of knowledge, who never gets in debt, who gains friends by deserving them, and who saves his money;" but, unfortunately for Cort, through his connection with Jellicoe he failed in the latter element of success.

So early as 1786 Lord Sheffield, of the Board of Trade, and a most distinguished writer on political economy, who died so lately as 1821, perceived the vast importance to the nation of Cort's improvements, and said in public:—

"If Mr. Cort's very ingenious and meritorious improvements in the art of making and working iron, the steam-engine of Boulton and Watt, and Lord Dundonald's discovery of making coke at half the present price, should *all succeed*, it is not asserting too much to say that the result will be more advantageous to Great Britain than the possession of the thirteen colonies of America, for it will give complete command of the iron-trade to this country, with all its vast advantages to navigation."

The peer he referred to as the discoverer of coke was the Scottish Earl of Dundonald, who, after serving in the cavalry, devoted a long life to scientific objects, chiefly with the view of benefiting the commercial and manufacturing interests of Scotland.

Cort states in his patents, that after great study and expense, "he had invented and brought to perfection a peculiar method and process of preparing, welding, and working various sorts of iron, and of reducing the same into uses by machinery: a furnace, and other apparatus adapted to the said process."

For anchors and similar iron-work, the fagots of piled iron were worked and welded into bars by rollers in lieu of forge-hammers; but it does not appear that there was any novelty in this use of rollers, as Cort refers to them in his specification as if already known. He had the merit of selecting and *combining* the best inventions of others, apparently, rather than of discovering much that was new.

An increased demand for iron was the result of all this, and hence the production of that manufacture, "which in the early part of the last century amounted to little more than 12,000 tons, about the middle of the century to 18,000, and at the time of Cort's patent to about 90,000 tons, was found in 1820 to have increased to 400,000 tons; and now the total quantity produced is upwards of *four millions* of tons of pig-iron yearly, or more than the entire production of all other European countries. There is little reason to doubt that this extraordinary development of the iron manufacture has been in a great measure due to Henry Cort; and it is said that at the present time (1863) there are not fewer than 8,200 of Cort's furnaces in operation in Great Britain alone."

Though the processes of Cort were discovered and adopted by others, the Lords of the Admiralty having, by persons appointed to test it, approved of his iron in particular, it was directed to be used alone in the navy for anchors and other iron-work, while numerous contracts for licences were entered into with Cort and his partner by the manufacturers of bar iron throughout the country. Cort now began to make arrangements for carrying on the manufacture of that metal on an enormous scale, and with that object obtained possession of a wharf at Gosport belonging to Adam Jellicoe, the father of his partner, when he succeeded in obtaining extensive Government orders for iron made after his patents, while licences were taken at royalties estimated to yield £27,500 to the owners of these patents.

Henry Cort seemed now on the high road to the realisation of

a princely fortune; "but there was a fatal canker at the root of this seeming prosperity, and in a few years the fabric which he had so laboriously raised crumbled into ruins; for, on the death of Adam Jellicoe, the father of Cort's partner, in August, 1789, defalcations were discovered in his public accounts to the extent of £39,676, and his books and papers were immediately taken possession of by the Government."

An examination proved that the debts due to Jellicoe senior amounted to £89,657, including the sum of £54,853 owing to him by the firm of Cort and Co., to which he had advanced money from time to time, to pursue experiments of an expensive character, securing himself, however, by a deed of agreement entitling him to one-half the stock and profits of all his contracts, and Cort subsequently assigned to him all his patent rights as collateral security. All this made the business connection a most unfortunate affair for him, as it was discovered that among the money advanced to the firm by Adam Jellicoe there was a sum of £27,500 entrusted to him for the pay of the officers and seamen of the Royal Navy! Embarrassments had fatally tempted him to make use of this money; and desperate attempts to set himself right only involved him more and more; the result preyed upon his health and shortened his life. On this discovery, the measures of the authorities were sharp and prompt.

"The body of Jellicoe was worth nothing to them, but they could secure the property in which he had fraudulently invested the public money entrusted to him. With this object the then Paymaster of the Navy proceeded to make an affidavit in the Exchequer that Henry Cort was indebted to His Majesty in the sum of £27,500 and upwards, in respect of moneys belonging to the public treasury, 'which Adam Jellicoe had at different times lent and advanced to the said Henry Cort, from whom the same now remains due and owing; and the deponent saith he verily believes that the said Henry Cort is much decayed in his credit and in very embarrassed circumstances; and therefore the deponent verily believes that the aforesaid debt so due and owing to His Majesty is in great danger of being lost if some more speedy means be not taken for the recovery than by the ordinary process of the Court.'"

The assignments which poor Cort had made of his patents were thus taken in security, while, most singular to say, Samuel Jellicoe, *the son of the defaulter*, was unjustly put in possession of the forges and mills at Fontley and Gosport, and continued to enjoy them, to the exclusion of Cort, for fourteen years.

It has been alleged that the simple process of demanding of the iron-masters who contracted with him their patent dues—amounting to £15,000 in 1789, to £15,000 in 1790, and to £25,000 in 1791—might have saved Cort from the irreparable ruin that fell upon him; but they were, however, prepared to dispute his rights at law, as they had been at variance with him.

"Mr. Cort has been most illiberally treated by the trade," wrote James Watt in 1784; "they are ignorant brutes; but he exposed himself to this, by showing them the process before it was perfect, and, seeing his ignorance of the common operations of making iron, laughed at and despised him; yet they will continue by some dirty evasion to use his process, or such parts as they like, without acknowledging him in it. *I shall be glad to be able to be of use to him.*"

It does not appear that more than £2,654 was raised from the ruin of Cort's estate towards the loss sustained by the public; and in 1805 the subject was again revived in a very unexpected manner, when the Whigs, in their attack upon the administration of Mr. Pitt, impeached Henry Dundas, Viscount Melville, for alleged malversation in his office as Treasurer of the Navy, though he held that office with success throughout the great naval war with France and Spain.

When Mr. Whitbread, the London brewer, spoke to the resolution for impeachment in the Commons, he averred that he strongly suspected "that Jellicoe was in the same partnership with Mark Sprott, Alexander Trotter, and Lord Melville, as he had been suffered to remain a public debtor for a whole year after he was known to be in arrear £24,000."

Bitter political enmity is said to have inspired Mr. Whitbread, whose speech was unwarrantable in tone, though serving its end, for Lord Melville was tried by his peers at Westminster Hall, and adjudged not guilty.

In the Report made by the Commissioners to the Houses of Parliament in 1805, the year of this remarkable impeachment, the value of Cort's patents was estimated then at only £100. Many of Jellicoe's debts were marked as bad; "and we apprehend," they added, "that the debt from Mr. Henry Cort, not so marked, of £54,000 and upwards, is of that description."

But all these parliamentary discussions availed Henry Cort nothing. With his wife and twelve young children he left his extensive works and handsome mansion, a bankrupt, ruined, heartbroken, and penniless. In vain did he appeal to Government for the restoration of his patents. However, Mr. Pitt granted him in 1794 a pension of £200 per annum; but, broken in health and spirits, he only enjoyed it six years, as he died in 1800, in the sixtieth year of his age.

"In the opinion of Mr. Fairbairn of Manchester," says the author of "Lives of the Engineers," "the inventions of Henry Cort have already added six hundred millions sterling to the wealth of the kingdom, while they have given employment to six hundred thousand working people, through three generations; and while the great iron-masters, by freely availing themselves of his inventions, have been adding estate to estate, the only estate secured by Henry Cort was the little domain of six feet by two, in which he lies interred in Hampstead churchyard!"

Such is the story of the man who founded the iron aristocracy of Great Britain. The small stone that marks his resting-place, with the date of his death, may still be seen. A few years ago it was quite illegible, but the kind hand of a relative has recently restored the inscription.

SHIP-BUILDING.—XVII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DECKS OF SHIPS (*continued*).

BEAM-END CONNECTIONS.

THIS branch of our subject is very important and extensive, so that no attempt will be made to exhaust it, but rather to illustrate arrangements which are, by common consent, pronounced good. Here, as elsewhere, we will take wood ships first, and afterwards pass to iron and composite ships.

Beam-end connections have long engaged the attention of wood shipbuilders, upon whose notice the matter has been forced by the weaknesses displayed by many vessels. In the old times, when the use of iron, except in the simplest forms, was unknown in ship-building, massive timber knees were used to connect the beams with the ship's sides. The beam-ends rested upon the edge of the internal planking, or "clamps," and were each secured by two knees—one (the "hanging knee") placed vertically, and bolted to the side of the beam and to the clamps; the other (the "lodging knee") placed horizontally, with one arm bolted to the beam and the other to the timbers. This clumsy arrangement has not yet fallen into entire disuse, but is adopted in some North American-built ships. In all probability the abundance and cheapness of timber there constitutes the chief reason for continuing to conform to the old-fashioned plan. In this country the departure from it was made long ago; and the plans which followed have in their turn been improved upon, giving place to others which are now in use. Our concern being chiefly with the latter, we will at once refer to an illustration, in Fig. 54, of the most improved beam-end connection, our sketch representing the practice of the Government service.

The beam-end is fitted closely against the timbers, great care being required in cutting the beam to the exact length required to ensure an accurate fit when the beam is set to the proper round-up. Underneath the beam-end comes the "shelf," *a*, a strong longitudinal timber, the lengths of which are joined by plain scarfs, well fitted and fastened. The shelf is usually fastened by a bolt in every timber, and also by circular dowels let half into the timbers and half into the shelf. It runs nearly the whole length of the ship from stem to stern, and constitutes a valuable longitudinal tie. Some shipbuilders have not entertained this opinion, and have not considered the shelf as more than a support for the beams; but in cases where this view has been acted upon, and the pieces of the shelf have been butted instead of being scarfed, exceptional weaknesses have been displayed. Sometimes the shelf is not worked directly against

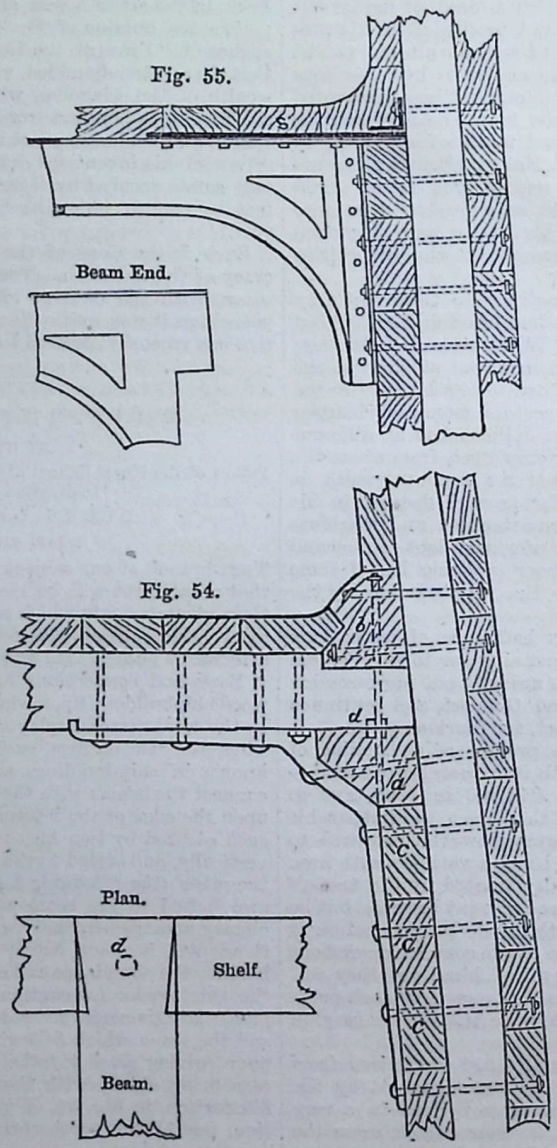
the timbers, as in the sketch, but is wrought inside the upper strake of the clamps, which then extend up to the under side of the beams. Formerly this plan was commonly employed, and the shelf-pieces were of smaller dimensions. A dowel (*d*, in the sketch) is fitted in the bearing surfaces of the beam and shelf; with large beams two dowels are usually fitted.

The beam-knee in this case is an iron forging fitting under the beam, against the shelf, and over the clamps. Its fastenings consist of several bolts with clenched points passing through the clamps or shelf, the timbers, and the outside planking, and of other bolts passing through the beam and clenched upon its upper surface. These fastenings are obviously well distributed, and, by retaining the knee in place, do much to aid it in resisting any change of angle between the beam-end and the ship's side. As compared with the older plans, this form of beam-knee is most simple and efficient, and it has come very largely into use in merchant ships as well as in wood ships of the Royal Navy.

The third element in the beam-end connection is supplied by the thick "waterway," *b* in Fig. 54. This large timber is faced, or let-down, over the beam-end, but the latter is not cut away, except to the small extent required to form the dovetailed seating (shown in the plan) upon which the waterway fits. The fastenings of the waterway to the side generally consist of a through-bolt in each timber, the bolts over the beams being driven in the upper edge of the waterway, and those between the beams in the lower edge. The separate lengths forming the waterway are plain-butted, not scarfed; but the butts are often dowelled to a carling fitted for the purpose, and are thus sufficiently strapped to enable them to contribute somewhat to the longitudinal strength of the structure. The union of the waterway, beam, and shelf, is further strengthened by means of the vertical through-bolt, shown in the sketch. Adjacent to the thick waterway, and let into its front, is the "thin waterway," which forms the side boundary of the deck planking; and directly above the waterway, the internal planking known as the "spirketting" is fitted.

From this brief description, it will be obvious that the beam is so secured as to be capable of acting either as a strut or a tie between the two sides, and that considerable resistance is offered to change of the angle between the beam-end and the side. It is by no means unusual, however, when wood ships have been severely strained at sea, to find symptoms of slight changes having occurred in this angle, even when the arrangements of Fig. 55—which are probably not far from the best possible with wood beams—have been adopted. One other noteworthy fact is, that by means of the strongly-fastened shelf and waterway, the relative positions of the decks and sides are maintained when the vessel is subjected to longitudinal strains, and so the strength of the decks is developed, notwithstanding their sheer.

Next we will take an illustration of the mode of securing iron beams in wood ships. Fig. 55 will aid our description greatly. The beam there shown is of the Butterley pattern, and has the knee formed by welding in a piece—as described in the previous paper—only a space is left unfilled when the welding is performed. Allusion was made to this practice before, and the openings so formed in the beam-arms are often found useful for leading pipes or other longitudinal fittings along close to the side, where they are out of the way. The beam-end is formed (as shown) with a shoulder, so that it may rest upon the upper edge of the clamps and have its upper part fitted against the timbers. Short pieces of planking are then worked above the clamps, and between the beams, thus assisting in maintaining the beams in place. The main connection with the side is made by double angle-irons on the beam-knee, fastened by rivets to the beam, and by through-bolts to the ship's side. Upon the beam-end, close to the timbers, is fitted a "stringer-plate," s, riveted to the upper flanges of the beam, and secured by an angle-iron to the timbers. This stringer consequently adds much to the strength of the connection, and acts as a horizontal knee to each beam. The latter feature of its usefulness is by no means unimportant, although subordinate to its office as a longitudinal strengthening. For instance, if a ship be heeled over, and at the same time subjected to longitudinal bending strains, there would be a considerable tendency to rack or distort the deck, and to throw the beams out of their transverse position. Against these racking strains the stringer, considered as a horizontal knee, would be most efficient, and, from its great breadth, would probably aid the beams much more than the waterway fitted on wood beams, although the latter gives valuable assistance under similar circumstances. The remaining details in Fig. 55 are sufficiently explained by the sketch; and it will be obvious that the whole arrangement is both simple and efficient, especially in its resistance to any change of the angle between the beam-end and the ship's side. Here the knee is formed as part of the beam-arm, and so shaped and fitted as to render working much less likely than with iron-plate knees and wood-beams, like those of Fig. 54. It is not surprising, therefore, to find that the use of iron beams in wood ships is becoming common; and it will be shown hereafter that other considerable advantages are also gained by employing them.



Iron and composite ships usually have their beams stationed at and directly connected with the frames. One illustration will, therefore, serve for both these classes, and it will be found in Fig. 56. Here also a beam of the Butterley pattern is shown. On referring to the beam marked *aa* in the plan, it will be observed that the web of the beam is fitted directly against the side of the frame angle-iron; that one of the flanges is continued on with the web, and that the other flange is butted against the reversed angle-iron. Should there be no reversed angle-iron on the frame at which the beam is stationed, it is common to fit the beam-web on the "back" of the frame angle-iron, instead of in its "bosom," as in the sketch. If made-beams, or beams formed of a bulb-plate and double angle-irons are used, slight modifications of the arrangement illustrated might be necessary, but these are unimportant. In nearly all cases the main fastenings in the beam-arm are rivets through the frames, spaced either as shown, or else zig-zag fashion, if the frames be of greater depth. The connection with

the side is strengthened by means of a stringer-plate riveted to the upper flanges of the beams; nothing need now be said respecting it further than that it acts similarly to the stringer in Fig. 55; but in our next paper we shall again refer to the subject.

It would be difficult to imagine any simpler or more efficient beam-end connection than that usually adopted in iron ships. Working in any direction is rendered practically impossible, provided that the beams be made sufficiently strong, the fastenings properly arranged, and the pillars carefully fitted. Moreover, it must be remembered that the bulkheads fitted in iron ships afford the beam-arms valuable assistance in preventing changes in the transverse form.

Besides the common mode of securing beams shown in Fig. 56, there are many other plans used under special circumstances. For example, the hold-beams of merchant ships, which are spaced very much farther apart than the deck-beams, are sometimes fitted above a "shelf-plate" (*i.e.* a stringer is worked below instead of upon them), and knees are consequently given up. Brackets or gusset-plates are then usually fitted instead of knees, and indirectly connected with the beams. In other cases no knees are formed on the beam-ends, but triangular-shaped bracket-plates are used instead, being riveted directly to both frames and beams. This connection is almost limited to made beams of I or box section. Other exceptional cases are met with in which the beams are not stationed at frames, but are directly connected with the skin-plating; and this plan was not uncommon in the earlier iron vessels. When special strength is needed, as is the case where beams form the boundaries of the principal hatchways, and for a considerable length there is no complete transverse tie, it is often considered desirable to strengthen the beams themselves, and to add to their connection with the side by fitting deep bracket-plates extending the whole distance between decks. These deep brackets are sometimes termed "partial bulkheads." Besides the above-named, there are other special beam-end connections, which cannot be noticed here; and our remarks on this subject must be concluded by stating that only unusual and unavoidable requirements lead iron ship-builders to depart much from the excellent plan in common use, illustrated by Fig. 56.

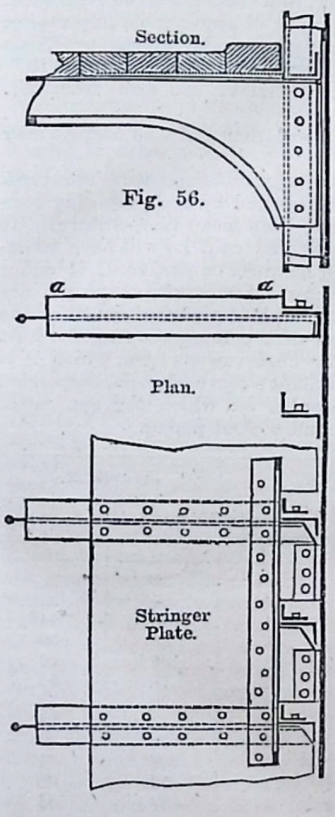


Fig. 56.

DECK-PILLARS.

Reference has been more than once made to the importance of efficient pillaring to the decks of ships; and a few words in the present paper will suffice to render this clear. Every one recognises the fact that pillars are needed as *struts* to support the decks, considered as platforms sustaining heavy weights; but many persons overlook the further very important consideration that under some circumstances the pillars must act as *ties* also, if they are to aid in preventing changes of transverse form. In order that these two requirements may be met, the pillars must be fastened at both their heads and their heels; but this is often left undone, and, as a consequence, the pillars can only act as struts, efficient against compressive strains.

Wood ships formerly had the pillars between decks, and the stanchions, or large pillars in the hold, were formed of wood; but now iron pillars, either solid or tubular in section, are largely employed. Iron and composite ships are always furnished with iron pillars. Tubular iron pillars are preferable to solid, especially for the larger sizes, because, with a given weight of material, they can be made much more efficient against failure by buckling under compressive strains, as well as against bending if struck horizontally. These hollow pillars can now be readily procured, and are largely used, especially in the Government service. The heads and heels are made solid, and forged similarly to those of ordinary solid or bar-iron pillars. With iron pillars it is possible to strongly bolt or rivet the heads to the beams, and the heels to the decks, or beams, or keelsons. Wood pillars cannot be so efficiently fastened; and, as usually fitted, they are not of service as ties against tensile strains. To secure equal strength they also require to be much larger than iron pillars, and this tells further against their use. They are now mainly used, if used at all, in the holds of wood ships.

In order to facilitate the work of pillaring it is customary to place the beams of successive decks directly over one another. The pillars are generally placed in rows, either at or on either side of the middle-line. The pillars, or stanchions in the hold, generally heel upon the keelson. At some parts of a ship it is difficult, if not impossible, to fit pillars to every beam. For instance, in the engine-room of a steam-ship, this is often the case; and it is then usual to fit longitudinal girders along under several beams, the ends of the girders resting upon pillars of exceptional strength. Where concentrated weights have to be supported, the pillars are, of course, both stronger and more numerous. All such arrangements rest very largely with the ship-builder, who can best determine as the work goes on where special strength should be given, and how it may be afforded.

SILK CULTURE.—VII.

By Alexander Wallace, M.D.

CULTURE AND MANAGEMENT OF THE BOMBYX PERNYI.

One more oak-feeding *Bombyx* requires particular mention, because it has of late years been the subject of experiment—viz., the oak-feeding silkworm of Manchouria and Northern China, *Bombyx Pernyi*. This name was given to it in honour of the French Archbishop Perny, by whose means this silkworm was first sent over to Europe. A few cocoons were at various times received in Paris, but though a few moths emerged, and eggs were obtained, the vitality of the parent insects was so depressed by the long journey that no healthy offspring was reared. A few cocoons, however, were forwarded to England by the late Mr. Meadows, H.B.M. acting consul at Newchwang, some of which were placed in my care. I therefore applied to the then Minister for Foreign Affairs, Lord Stanley (now Lord Derby), and he very kindly acceded to my request, and issued instructions to Mr. Meadows to forward to me for the next four years cocoons of this promising *Bombyx*, and also acorns of the oaks on which the worms were fed. Consignments of these cocoons in quantity have therefore enabled me to make a fair trial of its habits, to observe it closely, and to distribute the eggs of this species over Great Britain and Ireland, some parts of the Continent, America, Australia, and the Cape of Good Hope; and sufficient information is now obtained to enable us to judge of the value of the race for commercial purposes.

We will therefore first repeat here the information received from Mr. Meadows, and afterwards refer to our own observations.

In the commercial report for the year 1865, by Mr. Thomas Taylor Meadows, on the consular district of Newchwang, the most northerly of the ports of China opened to foreign trade by the Treaty of Tien-tsin, and situated in the Manchurian province of Tung-t'ien or Sheng-king, are contained some interesting details, derived from personal investigations, regarding "mountain silk," the product of the larvæ of a moth feeding on oak leaves.* "There are two crops of the mountain

* Mr. W. H. Lay, in his report on the trade of Chefoo for the year 1866, thus refers to what I suppose is the same production:—"Amongst the articles that can be exported from Chefoo there is brown silk, produced from the wild silkworms that swarm in the mountain forests; and the quantity of this article that could be brought into the market,

cocoon, a 'chun,' or spring crop, and a 'tsew,' or autumn crop. The latter is collected in the last half of September, and in October, and the cocoons are brought to market during this latter month. At this period the silk-growers pick out the best of the cocoons for the production in spring of the butterfly and worm for the spring crop. They are preserved in baskets, which are hung up in the Chinese dwelling-rooms. These almost always face the south, thus opposing a blank wall to the cold northerly winds prevalent in winter, and getting from the southerly windows the full advantage of the sun in that season, when, during nine days out of ten, there is a clear blue sky. Besides this the dwelling-rooms are partially heated by the warmth emanating from the surface of the "kang," or brick bench which occupies about one-third of the room, which serves as a sleeping-place at night, as seat, etc., during the day, and inside which is a winding flue with an aperture at one end in which a fire of millet stalks is occasionally lighted. In spite of all this, however, the temperature of a Chinese dwelling in the mountain-silk district is, during the greater part of the winter, considerably below the freezing-point. The worm, being indigenous, could doubtless stand the cold of the winter's night in its cocoon on the bushes on which the cocoon is formed; but apart from theft, destruction by wild animals, insects, etc., it is probable that in nights of unusual severity only the strongest and best enclosed might escape perishing from cold.

"The natural heat of spring suffices to bring the chrysalis out of the cocoon in the butterfly shape. The butterflies then couple, and in about four or five days after impregnation the female lays eggs. They are laid on native paper spread on mats, tables, etc. In about five or six days from each of these eggs is produced a small worm of about the size of a black ant, which is black in colour. This is about the time when the buds on the oak-bushes have begun to make their appearance: this must be in the last half of April. The young leaves are forced by twigs being cut off from the bushes and placed in water, in pools of the mountain streams, or in tubs in houses. From these the young tender leaves are taken, and are scattered over the paper as the worms appear from the eggs. The worms are thus nourished for some days, when they are transferred to the youngest, most tender-leaved oak-bushes on the hill-slopes. They are then about an inch in length, but are still black in colour. The transfer of the whole does not take place in one or two days. There is, during the whole existence of the animal in its worm stage, a difference of eight or ten days in the backwardness or forwardness of individuals.

"After some days the worm has its first sleep or torpor, at the close of which it changes its skin, and re-appears green in colour and larger in size. It has in all four of these sleeps or torpors, each of which lasts about two days. It changes its skin and becomes larger after each torpor, but retains, after the first, the same bright-green colour. For its next or fifth sleep it prepares by spinning itself into a cocoon, in which it assumes the chrysalis shape; then bursts out as a butterfly, and lays eggs, from which the small black worms are produced, when the processes just described are gone through again. These processes are, in the spring season, more rapidly performed than the similar processes in the autumn. The silk-growers told me that those of spring required about sixty days, those of autumn about one hundred. In each season, as fast as the worms consume the leaves on one bush they are removed by the attendant silk cultivators to another, the youngest bushes being used first.

"The worm is fed on three kinds of oak bushes called 'small tsing-kang-lew,' 'large tsing-kang-lew,' and 'hoo-pŏ-lŏ.' The only difference between the small and the large tsing-kang-lew seemed to me to be in the acorn cup, that of the former being smaller and also smoother outside than that of the latter. As for the hoo-pŏ-lŏ oak, its leaves are much larger and darker than those of the large or small tsing-kang-lew. Its acorns are also much larger, and, what at once marks the difference, the cup, instead of a hard exterior rendered more or less rough by small hard protuberances, is covered with longish feathery filaments, which give the cup the appearance of a small fur cap.

"The yield of the spring crop is said to be much less than that of the autumn crop—1,000 cocoons of the former giving no more than 500 of the latter; but the quality is said to be greatly superior, finer, whiter in itself, and more capable of taking dyes; but black, with various shades of reddish-brown or purple, seem to be the only dyes that either kind will take.

"The chrysalids which are not kept for breeding are used by the Chinese as an article of food.

"The mountain silk remains as yet the one article which this district is likely to furnish to England. My explorations of last summer convinced me that I did not, in my last report, over-estimate the extent of country in which it is produced, when I said 150 miles by 100. On the other hand, instead of saying that not one-fourth part of the hill-sides suitable for the oak-bushes is planted with them, I should now say that not one-tenth part is so planted. Viewing the nature of the article and the quantities that are now, and that could be furnished, the trade could be developed into one of appreciable importance even for our great manufacturing interests, unless exactions and jealousies of the local mandarins interposed to repress it."

The following remarks on the climate are also from Mr. Meadows's report:—

"The result of our five years' experience of the climate may be given here.

"The following is a table of the extreme temperature observed. It gives information much more required by the proposing resident or traveller in new countries than mean temperatures. It shows him what extremes of heat and cold he will have to encounter at times, and for which he must be prepared, or suffer severely in consequence. For mean temperatures people are rarely insufficiently prepared. The chief practical defect of the table is, accordingly, the absence of a column showing the heat of the sunshine in summer. The observations from which it is made were all taken from Fahrenheit's thermometers, suspended on the northern faces of house-walls, on which the sun never shines, therefore in the coldest and coolest places.

Month.	Coldest.		Warmest.	
	Morning at daybreak.	Afternoon at 2 to 4 p.m.	Morning at daybreak.	Afternoon at 2 to 4 p.m.
January	...	3°	39°	...
February	...	7	35	...
March	0°	14	43	44°
April	27	41	53	50
May	41	52	65	60
June	57	70	76	68
July	62	74	79	74
August	63	73	77	85
September	41	52	73	80
October	28	42	66	71
November	7	17	52	61
December	6	2	37	44

"The coolest months are December, January, and February. The greatest cold of a winter may occur in any of these months, but is most likely to occur in January and first half of February.

"The warmest months are June, July, and August. The greatest heat of a summer may occur in any of these months, but is most likely to occur in July and first half of August.

"The number of days in any one winter on which the thermometer stands at daybreak below zero does not exceed ten; and it rarely is below zero for more than two mornings in succession. In the coldest winter afternoon it always rises above zero.

"In a cool room with Venetian blinds the temperature does not rise above 80°, except for a few hours during some twenty-five to thirty-five afternoons in each summer, and these comparatively hot days do not occur together, but are distributed, with cool intervals, in groups of three to five, throughout June, July, and August. In these months the temperature always falls below 80° during the nights. In exceptionally hot summers, as in that of 1862, the thermometer may stand at daybreak at 75° to 79° for some twenty days; in cool summers it rarely stands above 70° at daybreak. As to the highest tem-

if prices suited, may be computed at not less than 12,000 bales a year. This silk is of different qualities, according to the process and care adopted in reeling it from the cocoons; and some of it is well adapted for manufacturers. The natives weave plain silk goods from it called 'pongees,' and about 100,000 pieces of these stuffs could be bought annually."

perature of the table, that of 85°, it has only once been attained in my library during five years; that was on 31st July, 1862."

All the preceding remarks refer to the climate of the port of Newchwang. The northern portions of the consular district of Newchwang are very much colder in winter, and have shorter and cooler summers.

The mean temperature of Pekin, as deduced by Kuppfer from thirteen years' observations, is—Spring 51° 8′, summer 68°, autumn 50° 4′, winter 29° 4′. A comparison of the temperatures of various European cities, as given in Mahlmann's elaborate tables, in the third volume of Humboldt's "Asie Centrale," will, I believe, prove my assertion.

It is therefore highly probable that on the hilly ranges where the *Bombyx Pernyi* breed the temperature will be found cooler even than that quoted by Mr. Meadows as peculiar to Newchwang.

The extreme hardiness of the race will first be noticed as contrasting greatly with the *Yama-Maï;* and all European experience bears me out in saying that this insect, in point of vitality and a hardy vigorous constitution, far exceeds the *Yama-Maï.* Indeed, the ease with which it has been transplanted, so to speak, into Europe, Africa, America, and Australia, and the difficulty which has attended the acclimatisation of the *Yama-Maï*, corroborates my statement that the *Bombyx Pernyi* is originally of a very vigorous and hardy constitution, and will thrive readily in other climates than its own. It will also be noticed that this insect is double brooded, and this, though an advantage perhaps in such climates as Australia and the Cape of Good Hope, which possess long summers and short winters, is a disadvantage in Great Britain, where our short and uncertain summer precludes the possibility of a second generation, except in very favourable seasons. This disadvantage also pertains to the *Bombyx Cynthia*, and, as in that insect, may be overcome by encouraging the adaptability of the race to the local peculiarity of the climate. Thus, by retarding the cocoons in the spring, and by adopting the same measures in the autumn, one generation can easily be obtained without much risk of a second. To this end the cocoons should be left in a cool cellar or out of doors in the shade, and in the autumn may even be preserved in sawdust in a hamper, and placed in a refrigerator, without detriment. This, therefore, is not the disadvantage practically which at first sight it appeared to be, and, as in the case of *Bombyx Cynthia*, an English acclimatised race of *Bombyx Pernyi* would gradually get accustomed to the climate and have normally but one generation. The climate of the country round Newchwang seems somewhat to resemble that of Northern Germany. The rainfall, as given by Mr. Meadows, is moderate, 22½ inches per annum being stated as an unusually high average; and a prevalence of strong winds is also noticed, which would materially lessen the temperature in the hilly regions where these worms are cultivated. It cannot, therefore, but be otherwise than that the temperature in these hills will have a lower average than that quoted by Mr. Meadows at Newchwang.

With regard to the oaks on which these larvæ feed, specimens of leaves and acorns have been sent to me and also to Kew Gardens, and from these materials the species of *Quercus* have been accurately determined. Two of these, called respectively, large and small "tsing-kang-lew," appear to be *Quercus Mongolica.*

Another, called "hoo-pŏ-lŏ," is *Quercus obovata Buuge.* The leaves of this kind of oak are larger and darker in colour than those of *Quercus Mongolica;* there is also a marked difference in the acorns, which are also larger and darker in colour, and covered with long and tapering scales, thus giving to the cup the appearance of being covered with long brown fur, which also partly covers the acorn itself. A fourth species, called "tseen-tse-tszeo," is the *Quercus serrata* of Thunberg. The silkworms fed upon this oak produce the best silk. This tree, however, is not so common in the silk districts as either of the other species. The next best quality of silk is obtained from the leaves of the *Quercus Mongolica;* those obtained from *Quercus obovata* producing the most inferior description. In this country the larvæ seem to prefer the leaves of the ilex or evergreen oak, also of *Quercus cerris*, the Turkey oak, and the variety known as the Lucombe oak; but it has also been easily reared on our common oaks, *Quercus pedunculata* and *Quercus sessiliflora.*

The cocoon is large and heavy, weighing from 80 to 200 grains, of a greyish yellow-brown tint. The inside cavity is much larger than the chrysalis, hence there is a danger in transporting these cocoons for a long distance, for the pupæ inside may get bruised and injured by the shaking endured in the journey. It is attached by a pedicle to the branch, and is thus intended to remain suspended (all the winter if necessary) till the moth emerges. It is of a somewhat loose texture, and the apex is less closely spun than the cocoon of the *Yama-Maï*, hence arises some little difficulty in reeling. The moth is large, pretty, uniform in tint, of a greyish brown colour, more or less suffused with reddish brown; the males have magnificent large antennæ-organs which, when largely developed, are generally concomitant with large powerful wings and a restless habit, intended evidently for ranging over large areas in search of the female.

A clear ocellus in each of the four wings, which are falcate at the tip and very powerful, make it a typical example of its genus, *Antheræa.* The female is large, sluggish in flight, full of eggs: the wings are broader and less falcate than in the male.

The egg is light brown, very like that of *Yama-Maï* in size and appearance, except being somewhat less flat and of a lighter tint. From 300 to 400 may be laid by one female. The egg state lasts in warm weather about fourteen days; and the larvæ hatch out in early morning, vigorous black little wanderers, restless in their habits, and partial to a drink, and even to consume their empty egg-shells; impatient till they get on to the oak leaves, where they mostly prefer to sun themselves on the upper surface of the leaf; gregarious at first, totally unlike in habits and appearance those of the *Yama-Maï.*

After the first month a great change appears, for the larvæ lose their gregarious habits, have a green tint, and almost exactly resemble the larvæ of the *Yama-Maï* to the end of their career, except that their heads remain brown and are spotted with darker markings, whereas the heads of the *Yama-Maï* retain a green tint, while underneath the body of the *Pernyi* a red chocolate-coloured central line is manifest, which is absent in the *Yama-Maï.* The general ground-colour has a more yellow tint, and the spines are longer, and clubbed at the tip like the antennæ of a butterfly. This is wanting in the *Yama-Maï*, and is indeed quite unusual in lepidopterous larvæ. They eat more and grow faster also than the *Yama-Maï* larvæ, are less inclined to drink, and much less prone to disease. Indeed, they have been very successfully turned out in this country on the oak hedges, and allowed to take their chance year after year, and have spun their cocoons. Just before spinning the larva is a monster in size; and as he prefers to take his station at the tip end of a spray from which he has eaten all the leaves, he becomes an easy mark to birds. In one very important matter this species is inferior to the *Yama-Maï*—the cocoon is not so easily reeled. Indeed, though the Chinese are said to reel this cocoon—and, according to Mr. Lay's report, the pongees, an article of considerable supply and demand, are made and woven from the silk to the amount of 100,000 pieces annually—we are yet unable in Europe to reel it, and this is due to the apex of the cocoon being insufficiently closed by the spinning larva. When this difficulty is overcome—which it will be one day—then the cocoons of *Bombyx Pernyi* will rise considerably in value. It has also another disadvantage: the colour is a greyish yellow brown, and not so favourable as that of the *Yama-Maï;* it is also less easily dyed. For carding purposes it has been very favourably spoken of by a gentleman who kindly experimented for me with some of the cocoons, and it produced a strong but soft and pleasant-feeling thread.

If, therefore, it could be produced in quantity at little cost it would prove a valuable commodity, wherever naturalised and localised, so that, without much labour or oversight, the larvæ could be reared out of doors on the trees, without destruction from birds and other enemies, in large numbers. If, in fact, the cocoons could be gathered from oak bushes much as gooseberries are gathered from their bushes, then, no doubt, a good profit would accrue. But this state of things can scarcely be hoped for in England, but rather might be looked for in Australia, New Zealand, or the Cape, where it is reported to me that the ailanthus silkworm, *Bombyx Cynthia*, is similarly cultivated. And with regard to these countries, those possessing the drier climate seem most suitable for the *Pernyi*, while the *Yama-Maï* would do best in the moister regions. It must not be lost sight of that the pupæ are reported to be consumed as food by the Chinese.

About this *Bombyx*, therefore, there seems to be much

promise. It is evidently a hardy vigorous kind, easily reared; and if, by its means, oak leaves can be converted into silken produce for the use of mankind, its value in the scale of creation is by no means contemptible.

PRACTICAL APPLICATION OF THE FINE ARTS.—XIII.

By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING.

INTRODUCTION—FOLDING—ARRANGING AND COLLATING—BANDS AND SEWING—FORWARDING.

It will be requisite, in order to show how the general principles of Art are to be applied to the special art of bookbinding, to describe in detail the various processes (in some cases very peculiar) that belong to this branch of industry. This will be the more requisite, not only because the majority of people know scarcely anything about the details of this art—which is not to be picked up by looking either at the covers of well-bound books, or through the windows behind which bookbinders are at work—but also more particularly because there are but few accounts in cyclopædias of the individual steps, and these accounts are all more or less imperfect, and brief even to obscurity.

The art divides itself at once into two branches, though there is much which is common to both these classes. These two divisions are *cheap* binding and *good* binding—not that it is necessary that cheap binding should be bad, it only does not partake of the strength and excellence of the good; but it is necessary that good binding should not be cheap, inasmuch as expensive materials and skilled workmanship, extended over a considerable time, must be employed.

Fig. 1.—SEWING.

Folding.—As is known to most persons, the paper employed by printers is of a few sizes, differing somewhat, but not greatly, from one another: these are called foolscap, crown (octavos, quartos, and folios), super-royal (27 inches by 19), imperial (30 by 21), foolscap (18 by 14), demy (20 by 15), medium (22 by 17), royal (24 by 19), columbia (34 by 23), atlas (33 by 26), double elephant (40 by 26), antiquarian (52 by 31). These sheets are simply doubled in half for folio, into four for 4to (quarto), eight for 8vo (octavo), in twelve for 12mo (duodecimo), into sixteen for 16mo, eighteen for 18mo, and thirty-two for 32mo, 48mo, 64mo (see Thumb Bible), lower than which we do not know that paper is ever folded. The folding is done by women, who have an instrument called a folder, or a folding-stick, like a small paper-knife, made of ivory, box-wood, or some similar material. The edges are neatly brought together, then the folder brought sharply up to the inside of where the crease is to be, and lastly run along the outside of the crease. The neatness and accuracy of the folding adds considerably to the beauty of the book, since, when the edges are all even it is only necessary to cut off a very small portion to make them smooth, and thus we get what bibliopoles call "a tall copy." There is much difference amongst women as to the number that they can fold in a day. A quick hand will fold as many as 3,000 sheets a day, though some do only half that number.

Arranging and Collating.—As soon as the sheets are folded, they are arranged according to the letters, called *signatures* or *catch words*, at the bottom of the first page of each sheet. This work is also done by girls; and in some cases as many as 25,000 have been gathered by one girl in a day; but the girls' work is afterwards examined by a superintendent, who also cuts out any portions left blank by the printer in the first or last sheets. In the case of maps, diagrams, and illustrations, these have to be added afterwards, and this is done by the *Collator*, who cuts the engravings to a size which will bring them to the middle of the page when the rough edges of the book are cut off. Naturally this requires great care and some experience, so as not to cut too much, and so thrust the print too far into the book to be seen with advantage, nor to leave it out so far that the edge is left narrow.

Bands.—The book is now returned to the women's department—after being beaten, pressed, or rolled between cylinders—and it is sewn upon the bands. These bands differ in number, according to the size of the book and the character of the binding. Cheap school-books, for instance, sometimes have only two bands, but most books have four or five, whilst large, strongly-bound books require six. The bands are pieces of strongish string, or cord, which are fastened perpendicularly at fixed distances on a frame rising at the edge of a board, on which the sheets of the book are placed one by one. A sheet is placed on the board, with its folded back against the upright bands; it is then opened by the left hand of the operator, who with her right hand runs a needle, threaded with strong thread, through the sheet against the first band, to which the thread was originally attached. The needle is brought out beyond the second band, around which the thread is passed, and the needle again enters the middle of the sheet, and passes on to the next band. When the last band is reached, the next sheet is laid on, opened as before, and the threaded needle passed from band to band the reverse way. The ancient binders carried this sewing up to the headings of the pages, around which also they passed the thread; that process (called flexible, or monastic) is abandoned now, and the little piece of vellum, bound round with silk, at the top and bottom of the book is now added at a later period of the process. In the best binding the hole for the thread is made by the needle, and the band stands off from the back of the book, whereas in the cheaper and quicker work all the holes are made at once by a saw passed along the back, and in the groove thus made the band lies. The disadvantage of this step is, that the book will not lie so flatly open. When the whole of the sheets are sewed, the bands are cut off at some little distance from the book, and the ends thus left are afterwards unravelled, and spread out, so that they may catch as firmly as possible on the boards when glued for common binding. For good binding the slips are drawn through the board. When the book is sewn, but the leaves are still loose, the back is covered with glue, which penetrates some little way between the leaves, joins the various sheets together, and fixes the plates, etc., in their places. This glue must dry, and then the book goes to another department.

Forwarding.—The book now passes from the women to the forwarding room, where several processes occur. First it is pressed between two wooden boards, about three-eighths of an inch of the back projecting beyond the boards, one-eighth to 8vo, and so on according to the thickness of the millboard. The workman

then, with a short-handled, heavy hammer, having one face large and flattened, and the other a blunt edge of nearly two inches wide, beats down the leaves, beginning with those nearest the boards, over the edge of them. This is first done with the edged face, but when the whole of the leaves have been beaten so as to incline to one side or the other, the whole is made into an even curve with the flat face. The process of beating the side leaves will have brought up the middle sheets, and will have caused a corresponding concavity in the front of the book. There is some little knack required in this process of beating down the back. A clever workman will, with a considerable number of blows adroitly given, beat the whole line of the back, so that when the book is opened wide the crease at the back will appear quite straight and even; but in a badly-bound book, done rapidly and carelessly, the crease will be irregular and uneven. To judge of whether a book is well bound or not, it is necessary to open it wide in several places; if it lies flat when opened, and the crease is one straight line, the work is good; but if the book closes itself, and has a number of irregular creases, it has been done quickly and unsatisfactorily. The wooden boards, too, by their pressure, will have left an indentation, into which the backing-boards, which are now always made of millboard, of greater or less thickness, can now be inserted. The monkish binders used to use wooden boards not unfrequently, but these are never employed now unless to humour the fancy of a customer. These boards have holes, through which the bands are inserted and glued. The leaves have now to be cut. The whole back is now rubbed hard with stiff paste on the glue, which has dried, and has been beaten round. This paste not only adds to the adhesiveness, but it also makes the glue less brittle and less liable to fall off. The cutting of the edges is done by pressing the book again between the two boards, one projecting beyond the edge of the book, the other being accurately placed on the line which it is desired to cut. A knife, which is fixed in a wooden machine to work evenly on the board, and is called a "plough," is passed backwards and forwards along this edge, until the whole book is cut through to the opposite board. This process is easy enough with the two ends, which are flat. With the face, the only requisite is to beat the back flat before the book is screwed up tight; it then makes the face flat after it has been cut straight; on the book being allowed to take its original curved shape, the front edges adopt the corresponding curve inwards. The edges of the leaves can now be coloured. Sometimes they are only sprinkled. This is done with a large hog's-hair brush, partly filled with colour, and jerked over them. The ancients used sometimes to blacken the edges with antimony in fine powder, rubbed on the damped edges, and burnished. Sometimes vermilion is rubbed on, with a little mucilage to make it stick. This too is burnished until it shines. Occasionally, in addition to these red edges, but more frequently without the red foundation, after having been simply rubbed with yellow-red ochre and size-water, the edges are gilt, which process is the same as ordinary gilding. Some white of egg thinned with water, or some similar mucilage, is applied to the edges of the leaves, and the requisite amount of gold leaf laid on. This gold is dried, and then burnished with a dog's tooth, agate, or bloodstone; and when the book is opened each leaf takes its own little modicum of gold. In some rare cases the edges are scraped before they are gilt. The most curious process is that of marbling, which is performed in the following manner:—A strong ley is made of linseed and fleeseed (gum tragacanth is the best); this should be of the consistency of cream, or thereabouts, and is spread over the surface of a wide but shallow trough. In the meantime colours are prepared by being ground very fine, with a small portion of ox-gall. These are thrown one after another on the surface of the ley, a little more ox-gall being added to each as it comes later in order. Those colours are left till the last, which appear most in spots on the top of the streaks of other colours. The ox-gall prevents the colours from mixing with one another, or with the somewhat oily mixture below; consequently each takes its own place in spots or streaks, as it may be thrown on the surface. We now have on the trough a surface of many colours, in those peculiar shapes we call marbling; all that remains is to dip the edges of the book, and the front, flattened as before, when it

Fig. 2.—FORWARDING.

Fig. 3.—FINISHING.

had to be cut, upon this coloured surface. The embossed surface takes up the colour to which it is applied, and only requires drying and burnishing. Considerable variety is caused in the character of the marbling by inserting a comb, and with it a slight amount of streaky small curve-like waves are produced; or by putting a stick in various places, and in each obtaining a little vortex around it; or by similar means: by tilting the trough a slight wave is produced, which will cause lines of greater or less intensity of colour. In this remarkable and amusing process there is plenty of room for ingenuity and taste, and an experienced workman may obtain considerable credit for his combinations of colour and form; whilst to the spectator beholding the process for the first time it is certainly a source of much amusement. When all the books have been marbled that are ready at the time, the remainder of the colour can be used up in staining paper for the insides of the covers, or for similar purposes.

The edges being coloured, the backs and boards are washed over with size, and are ready to be transferred to the men who put the actual cover on the book, be it leather, cloth, or paper.

As this introduces a new and a lengthy subject, we must reserve it for a future paper.

SANITARY ENGINEERING.—XXIV.

THE VENTILATION OF SEWERS.

Of all the questions involved in theories of sanitary engineering proper, this may perhaps be considered the *crux*, or crucial difficulty. The unwholesomeness of sewage arises from the deleterious gases evolved from fæcal or decomposing animal matter. Supposing, therefore, sewers to be thoroughly ventilated, these noxious elements are of course removed, and dispersed in the surrounding atmosphere, and the sanitary success accomplished. We are far, however, from having hitherto arrived at that desirable conclusion; and let us first remark that the circumstances to be dealt with are very different from those attending an ordinary limited area of house-drainage, which, by the judicious application of certain well-understood principles, may be made self-ventilating by the adoption of the methods indicated in our late paper upon the subject, or in some similar way; and we at once illustrate our meaning by referring to what is still the standing authority upon the question, the Report of W. Haywood, Esq., Engineer to the Commissioners of Sewers, published in 1858. At page 51, he says: "There are in the City of London 45½ miles of pipes large enough for men to enter, and 2½ miles of pipe sewers. To these sewers there are about—

2810 gullies of every description;
1065 air-shafts, with ventilators.

3875 openings to the sewers from the public ways."

And, by a further calculation, he arrives at the figures, that the total length of house-drains existing in the City must be about 168 miles. All these drains, of course, are more or less pervious to the external air, either from defects in the construction, bad jointing, imperfect trapping, or the absence of any trapping whatever—though this last defect is, no doubt, far less prevalent now than at the time when his Report was made, fourteen years ago. Yet we may take it that the extent of the drainage system, and most of its general conditions, are much in the same state now as they were then, though, doubtless, there have been many modern improvements introduced in matters of detail. Our object is not, however, to report upon the present condition of drainage in the City: we simply quote the figures as supplying some sort of basis upon which an idea may be formed as to the difficulty of the general problem—the ventilation of sewers. Various schemes have been propounded at different times, many of them fully considered in the Report above quoted; and we may venture to say that the conclusion to which most authorities upon the subject have arrived is, that the ventilation of any existing system of sewage must be a carefully considered question of detail. We instance the City first, as there—probably from the large proportion of population to area, the confined width of many of the streets, and various other local causes—the difficulties that have to be met are at least as great, if not greater, than are to be met with elsewhere; and yet we may state, without contradiction, that the hygienic statistics of the City contrast well with many other portions of the metropolis, and are in satisfactory advance of some of our larger provincial centres. Ventilation by means of an air-gully in the centre of the street, at certain intervals guided by circumstances, aided occasionally in very narrow throughfares by ventilating pipes conducting the sewer emanations to the level of the chimney-tops of the adjoining houses; a careful attention to flushing and cleansing the drains as requisite, and an abundant supply of water, may be mentioned as the most efficient means, either in London or elsewhere, of providing for the easy and innocuous escape of sewer gases.

The currents of air that travel through the sewers are subject to the most uncertain laws. This fact, however, seems to be established, that in any district in which there is considerable variation of level, the usual course of matters is this: the ventilating gullies in the upper portion of the district act as up-cast, and in the lower portion as down-cast shafts. But we may broach the theory here, that the more a district is subdivided, and the more ample provision is made for the self-acting ventilation of each particular section, the more perfect the result is likely to be. Experiments were made in Paris, and also in Antwerp, many years ago, with a view of ventilating a large area of sewage by a lofty chimney, the ventilating power being either a furnace or a fan driven by mechanical means; but in each case the result was only partial; as we may well imagine that the influx of fresh air necessarily created by the powerful draught from the numerous openings and gullies neutralises its effect beyond a comparatively small radius of the centre of its sphere of action. We may ask our readers—especially those with some technical and mechanical knowledge—to refer to the figures quoted above as relating to the City of London, and judge for themselves whether any system of artificial ventilation from a central point does not strike them from the first as chimerical, if not on the score of feasibility, at all events on the score of expense. Many such ideas have been started, and some of them are fully dealt with in the Report we have quoted above, and from which we again append the result of some valuable observations as to the comparative temperature of sewers as compared with the upper external air at various seasons of the year. We find at page 84:—"Inspection of the tables will show that between 9 a.m. and 6 p.m. of some days of the summer months, when the external temperature at the period of reading ranged from 55° to 72°, the mean being 65°, the mean temperature of the sewer was 62°, or 3° below that of the open air;" and the Report goes on to show that when such a state of things existed no ventilation could be depended upon for an up-cast draught, and therefore the effluvium from the sewers become unpleasantly evident. Also, further:—"The mean temperature of June, July, and August, registered at Greenwich for a period of fourteen years, was about 61°; the mean temperature of the sewers during those months may be taken as about the same. Thus, during three of the most important months of the year, when the nuisance from sewers is the greatest, these shafts would be useless."

The average difference at night between the minimum open air temperature and that of the sewers may be from 12° to 15°, and therefore we may fairly assume that any system of ventilation, as adapted to sewage, is more efficient at night, although, as we have shown in previous papers, the actual quantity of sewage passing is very considerably less in the night than during the day. "A difference of 6° may be said to exist throughout the year."

It must also be borne in mind, in dealing with all questions of the ventilation of sewers, whether in London or elsewhere, on an extensive scale, that we have not a new, recently erected, well-considered, and complete scheme of construction to deal with, but in many instances, we might almost say, a thing of shreds and patches, the date of many improvements being each marked by the class of work done at that particular period. Many of the sewers now actually in use in the neighbourhood of London were constructed more than fifty years ago, and have all the defects in section and construction of old-fashioned work of that date. So much for actual structural difficulty as to any combined system. With regard to the control of matters in detail, we again quote:—

"I do not anticipate that the three-quarters of a million of inlets to the metropolitan sewers can be by any amount of inspection kept in such a perfect condition that imperfect traps in houses, inoperative gully-valves, the opening of side entrances, the reparation of drains, will not cause a vast amount

of leakage which will present one of the principal if not the main difficulty to be overcome." Now in this element of what is called leakage lies, to our mind, one of the greatest elements of actual assistance to the ventilation of sewers, as considered in detail; for be it remembered, that as the foul air escapes it must be replaced by fresh in some way or other; and this object once attained to a sufficient extent, the only other object is so to arrange matters that the foul air may be allowed its vent at points where it is least perceptible to the public—or we should rather say, least deleterious—and we most emphatically protest against any attempt at hermetically sealing any very large section of drainage of any description whatever, where natural ventilation only is employed; as, if this is done, should a defect exist anywhere within the limits of a private house, most disastrous results may be expected to arise.

The foregoing remarks may be taken as applying to any extensive system of sewers, either in the metropolis or in the great provincial centres. In country towns, where there is abundance of air-space, the same difficulties do not exist in the same degree; but at the same time, bearing in mind the risk arising from the fact of any system of drainage communicating with houses in which stoneware drains are used, the necessary precautions for the escape of the gases should never be neglected, and there are some peculiar conditions under which express attention to this point is very desirable—*e.g.*, in all cases which are subject to tidal influence. Many of our sea-port towns which drain into the sea, discharge only at the time of low water. As the tide rises the sewage in the drains finds its level, and perhaps for several hours out of the twenty-four the lower section of the pipes does not discharge, but becomes for the short period in question a mere receptacle for sewage. In these cases a special provision for ventilation by means of shafts or otherwise is very desirable.

The circumstances under which different systems of drainage have to be constructed vary so entirely that it is impossible to lay down any fixed method for general adoption. Our object has been to point out the nature of the danger, and to indicate the general principles to be adopted for sanitary protection. Closely allied to the question of the ventilation of sewers is that of the disinfection of sewage gases. We have already alluded to the subject, and given some general data in relation to house-drainage only. In our next paper we shall take up the subject of disinfection of sewage, solid and liquid, upon an extensive scale, giving an account of some of the largest operations now carried on for the purpose in the metropolis and elsewhere throughout the country.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XI.—NATIONAL MUSEUMS (*continued*).

Style of Architecture.—Not being conversant with architectural construction, I have only indicated the requirements of curators in the preceding description of what modern naturalists conceive a national museum of natural history should comprise, without attempting to indicate in any way how such a skeleton should be clothed with the garments of art. The Pointed Gothic style of architecture is much in vogue at the present day, as it is said to be "an elastic style," readily adaptable to any requirements; but it seems to me that the so-called "Palladian Style" (illustrated at page 9, Vol. IV. of THE POPULAR EDUCATOR) is well adapted to the plan of building previously described, as it is two-storied, with unencumbered windows, admits of a cupola, bold portico, statues of celebrated naturalists, preferably on the pedestals of the balustrades than among the chimney-pots, or, as at the University of London, in niches, that would help to break the lower line of wall below the windows, as these, by requirements of wall-cases, can only commence nine feet from the lower floor. In short, it is simple and inexpensive, yet withal bears a classic aspect.

As to internal decorations, a hint might be taken from the Oxford Museum, especially if the Gothic style be adopted—viz., to utilise all shafts, pillars, etc., for the illustration of petrology, by making them of various kinds of granite, serpentines, marbles, limestones, sandstones, slates, conglomerates, etc., of the different geological formations, and crowning them with capitals and corbels, carved with natural objects, representing chiefly groups of typical plants, sometimes with animal forms geographically and naturally associated with them, as *Bromus* (wheat, barley, oats, Indian corn, and sugar-cane) with sparrows; rice, and canary-grass with buntings, canaries, and quails, similar to a typical illustration of *Gramineæ* that ornaments the capital and corbels which surmount a shaft of Limerick mountain limestone at the Oxford Museum. If the University of Oxford can afford thus to deck its sanctuary of science, surely the British nation can follow its example. Dr. Acland's "Remarks on the Oxford Museum" are well worth consulting by all persons interested in the decorative details of museum architecture.

Details of Gallery Construction.—On referring to the "Estimate of Space for New Museum," Vol. III., p. 320, it will be noted that the length of certain galleries would have to be increased by the re-distribution of other departments, according to the requirements of modern naturalists. Thus, mammalia requires a length of 850 feet; to this Professor Owen adds 550 for mammalian osteology; and the memorialists of 1858 would make a considerable further addition by blending the fossil with recent mammalia, together with dissected and embryological preparations, models, etc. In other groups mimetic illustrations must be added. As it would be impracticable to have galleries of, say over 1,500 feet in length, of one class, the required length must be gained by the system of reduplication of wall-cases, pre-

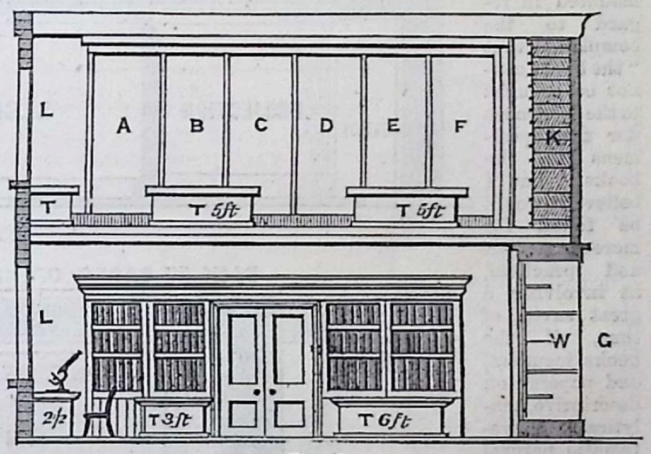


Fig. 7.

viously described, and now shown in Figs. 8 and 9, whereby in a straight length of 35 feet a frontage of even 115 feet could be attained *on each side* of a gallery, by throwing out the projecting cases 20 feet, or a total frontage of 230 feet, with space for table-cases in each recess. In the latter case each bay would constitute a separate room, with a gangway 10 feet wide. For cleanliness, the space above the cases might be covered with Minton's plain or ornamental tiles, and white ones where reflected light was needed.

Details of Studies and Keepers' Rooms.—The arrangement of the private rooms is shown in Fig. 7, in a section taken at right angles to Fig. 8. They are arranged on two floors, the lower one being the study, reached from the public gallery, and devoted to the same class of objects; the upper floor being the workrooms of the keepers, assistant-keepers, and other officials—the communication between the two floors being by a spiral staircase. The studies are filled with tables, T, of various widths—two, three, and six feet—facing lofty windows, L, looking out upon the interior open court. These tables should be supported on blocks fitted with store drawers, with interspaces for chairs, to keep each student's space distinctly separate; the tables next the window being devoted to microscopic or other minute examinations, those farthest away for the larger objects. Each end of the studies would be fitted with book-cases for the special class-libraries, placed on each side of the intercommunicating doors. Every study should be supplied with dissecting and compound microscopes with powers and appliances suited to the special class of study, as, for instance, goniometers, polariscopes, etc., in the mineralogical studies.

The official apartment above would be fitted round with presses,

A to F, for drawers, trays, book-boxes, etc., according to the nature of the objects to be stored, and from this room access would be obtained to the store-cases, K, ranged behind the wall-space above the wall-cases, W, of the public gallery. In fact, the principle of arrangement of studies and keepers' rooms would be to *make provision* for every available space being utilised for storeage according to the progressive annual increase of the collections. By this arrangement the work of the keeper and his officials need not be interrupted by the advent of students or naturalists with whom the staff might be personally acquainted, except to meet their special requirements for information, as subordinate attendants could supply the wants of those visiting the studies.

Details of Library.—In all the plans hitherto proposed provision has been made for a central library from which books could be taken to the studies, so that the difficulties experienced at the British Museum might be surmounted in regard to the complaint that "the books cannot be brought to the specimens nor the specimens to the books;" but I believe it would be found far more convenient and practical, as involving a great saving of time, if the books, memoirs, and papers* on descriptive, analytical, and systematic natural history, were distributed among the studies according to the subjects to which they specially pertained, so that each study should contain its own special bibliography—an opinion in which I am confirmed by Professor Agassiz, who has recently re-arranged his museum library on this system. Each study should be supplied with geological and physical maps showing the distribution of the class of objects it contains. Works on general natural history might be consulted in a small library attached to the private rooms of the heads of departments placed in the supplementary buildings, B (Fig. 4).

Professor Owen considers, that as ninety-nine out of a hundred who would consult the "Banksian Library" would be naturalists, it ought to be removed from the British Museum Library, and go with the natural history collections to the new Museum, especially as Dryander's very perfect printed catalogues of that library are in the possession of most naturalists. If this were done, the cost of a duplicate natural history library of modern books, etc., for the new Museum has been estimated to cost £10,000.

General Details of Arrangement.—"Wall-cases" with hermetically sealed glass fronts and back entrances to allow of specimens being removed into the studies, have, from their close association with the subject of construction, been previously described; but it is right to notice the objections that have been raised to this kind of case by Dr. Wallace, with which many other naturalists agree:—

1. They admit of any object being seen by the smallest number of persons at once, so that any one person studying an object almost necessarily monopolises it, and prevents others from approaching it, an inconvenience that reaches its maximum in the recessed cases exhibited in Dr. Sclater's plan.

2. Objects in wall-cases can be seen only on *one* side, which, as *all* sides of natural objects require to be seen, would necessitate many specimens to do the duty of one.

3. The observer on the one side from which alone he can see an object will generally stand in his own light, and will often have distinct vision further impaired by reflection from the glass.

4. When small objects occur alternately with large ones, a great waste of space occurs, and the attention is distracted from the less conspicuous object.

Objection 3 might be obviated by placing two wall-cases to the right and left of a window, and at right angles to it. The wall space then given up to window space might be made up for by placing a narrow floor-case between the two wall-cases. Thus arranged, two wall-cases would stand back to back between each window-pier, on the reduplicated system.

It only remains to note that internal metal fittings must be provided, to allow of the shelves being set at suitable heights, angles, etc., that bars pierced with holes for the reception of small socket-pieces and their clamp-screws, may in many instances be screwed near the fronts of the cases for the reception of small trays adjustable both for distance and angle, and swivel rods for suspending specimens in suitable positions. When the general run of objects in a class is small, "dwarf wall-cases," similar to that shown in Fig. 10, may be advantageously placed around the galleries. The tops of such cases are only as high as the level of the eye when an adult stands erect. The upper part is fitted with shelves six or eight inches wide, adjustable to any angle; the lower part is wider

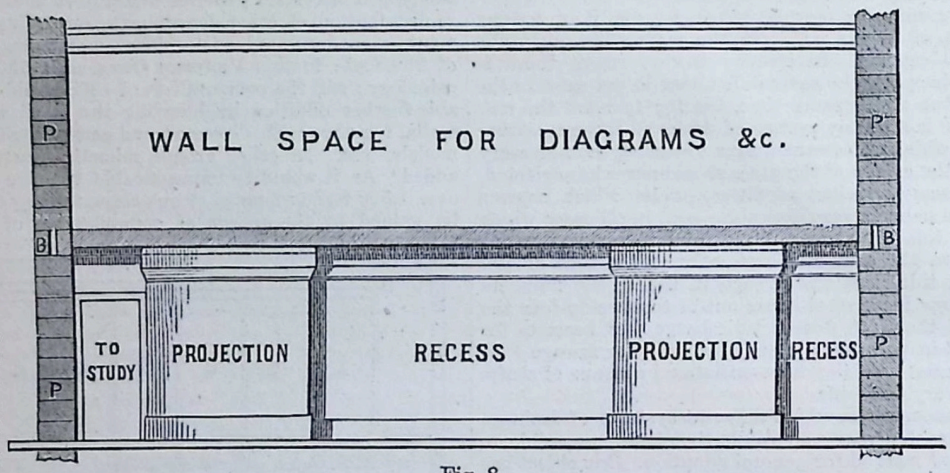


Fig. 8.

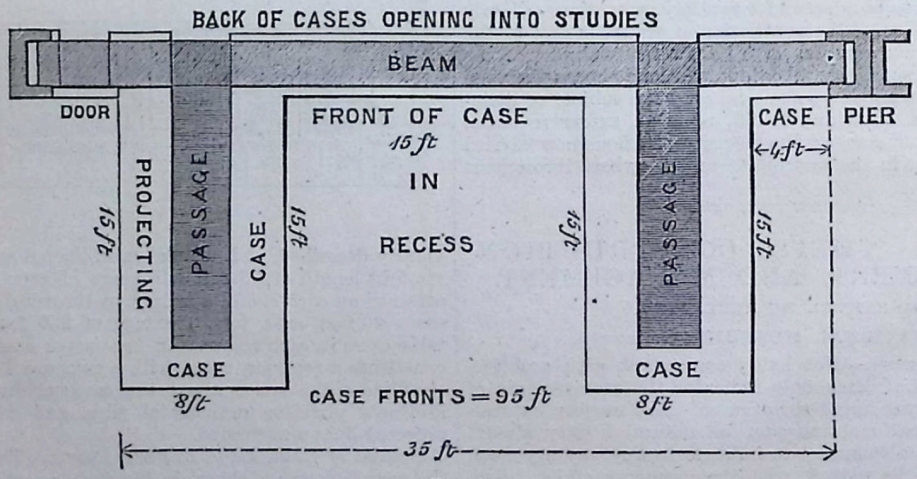


Fig. 9.

* Two sets of all the scientific periodicals, reports, etc., would provide for each scientific paper being separated and bound up in separate form, or, if short, with other papers of an allied character on the same class, and deposited in its appropriate class library.

by eighteen inches, forming a shelf that can be looked down on; beneath this it is filled with drawers: the whole of this arrangement can be fitted into the partition that separates gallery from study, so that shelves and drawers are alike accessible from the studies only.

"Floor-cases" (Fig. 13), are very convenient for the display of the vertebrate classes. Such cases should be ten feet long by seven feet high, the width varying according to absolute requirement, if arranged in a manner similar to that recommended for table-cases presently decribed, as in Fig. 14.

To meet special requirements these may be made shorter, so that two cases may be grouped in the same space as a 10-foot case. This allows of scarce specimens—such as the gorilla group in the British Museum—being viewed on all sides; for the same reason one specimen may be made to do the service of two, when both its sides should be examined. Again, in some instances the length may exceed the standard length of ten feet in making provision for the walruses, cetacea, or the height, as for the giraffes. In the new Museum the floor-space of each class gallery must be occupied by specimens belonging to that class, not as at present, corals with mammals, oysters with "oyster catchers" of the avian class, etc., to the utter disregard of that method of silent instruction which may be conveyed through the eye by the proper association of allied species. Such floor-cases must replace the present table-cases, to give cover to new specimens that must replace the mangy cows, and the hippopotamus. These cases must be fitted up with shelves, blocks, suspending rods, etc., according to requirement, to meet the proper height or angle for the most efficient display of objects.

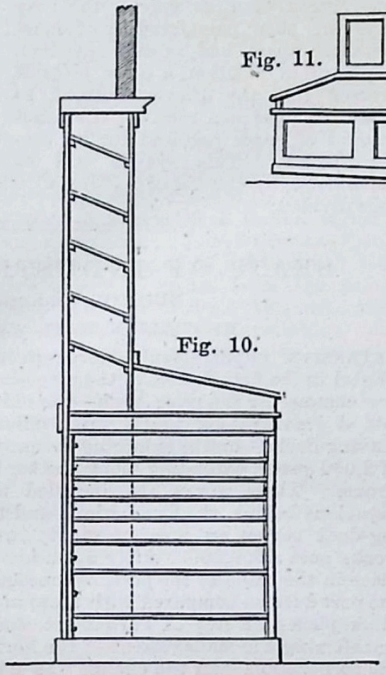


Fig. 10.

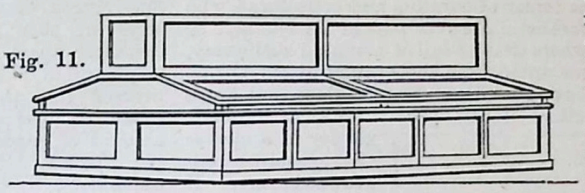


Fig. 11.

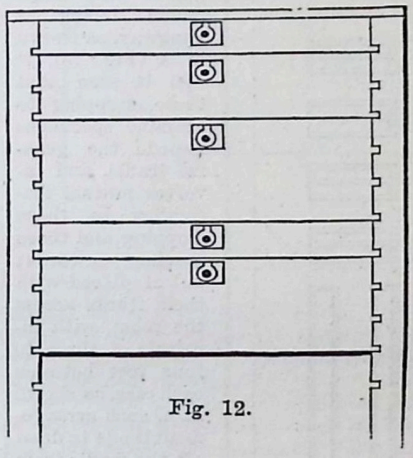


Fig. 12.

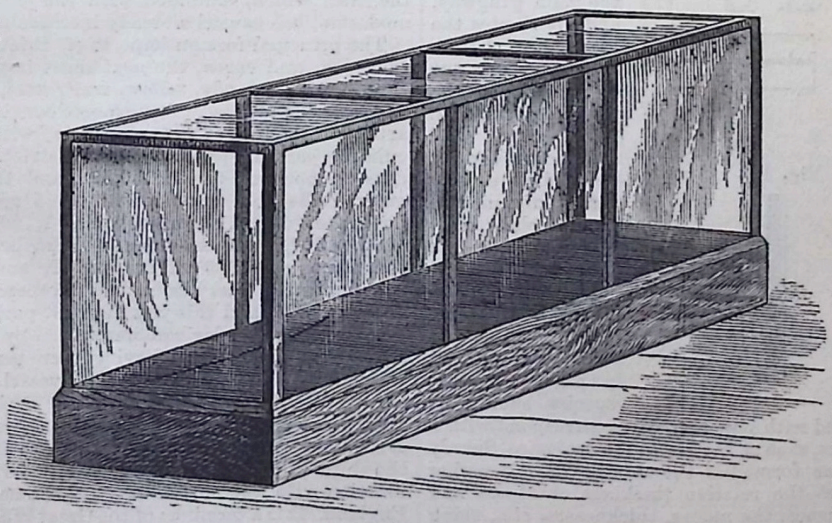


Fig. 13.

"Table-cases" are extremely convenient for the examination of small objects requiring a top light, such as most of the invertebrates, minerals, sections of woods, etc. A good model is shown in Fig. 11, which is 10 feet long by 5 feet 5 inches wide, by 5 feet 10 inches high, filled beneath with drawers.* The upper part may in some instances be replaced with shallow trays, or altogether dispensed with. The best plan for excluding dust from cases that must of necessity be opened at times in a public gallery, and the flap-lids or doors of which are usually permeable, is to line the flat surfaces on which the doors or flaps shut with felt, as this entangles the dust driven inwards by any draught, and if this be combined with a valley-and-ridge fitting the case may be regarded as hermetically sealed. The most convenient way of fitting the drawer space beneath for systematic natural history purposes is to groove the sides at exact intervals of an inch, for the reception of fillets placed on the sides of the drawers, trays, etc., as shown in Fig. 12. The drawers, etc., must be made an inch or the multiple of an inch in depth, so that according to the depth of the largest specimen in any series of objects, a drawer of suitable depth may be selected, to allow such object falling into its exact systematic position, instead of being placed in a supplemental drawer for large objects, as would have to be the case if the drawers were made in the usual way all of one size, or of gradually increasing depths from top to bottom of a tier, which is palpably an unpractical arrangement, as the curator or collector, in classifying his objects, is forced to group large and small specimens in the same drawer, or one drawer may contain shallow specimens, and the next large ones, and if all the drawers were made equal to the depth of the largest object in any given series there would be a palpable loss of cabinet space. By my method, shown in Fig. 12, it will be seen that the curator can "cut his coat according to his cloth," and select drawers according to the exact depth the largest specimens in a group necessitate: thus the first drawer may be one inch deep, the next two inches, the next three inches. Again, having arranged a series of objects, if it becomes necessary to intercalate a fresh group, it is not necessary to re-arrange the entire series of specimens, but simply to remove the drawers below the point where the new group is to be inserted, and to replace the drawers in advanced order. This method applies to drawers, trays, etc., in cabinets, store-cases, table-blocks, and, it will be seen, involves a vast saving of valuable space. I need hardly say it requires good cabinet-work, and strict attention to standard gauges, when in a large series of drawers one may be taken from one part of a room and placed in another block without the drawers sticking, and a certainty that the fronts of the drawers will fit close under each other so as to exclude dust. Agassiz, in a recent Report, calls attention to the loss his museum has recently sustained through the access of moth, etc., to a great

* This is the form adopted at the Liverpool Free Public Museum.

extent due to bad cabinet work; and he says, "It is true, and worth repeating, that the more expensive way of putting up specimens, viz., in good and costly cases or boxes, is in the end the cheapest mode, saving time as well as specimens." If a cabinet of drawers is properly made each drawer should glide in and out without jarring, sticking, etc., even if moved to and fro by one handle only. Great injury may be done to a collection of insects, delicate shells, etc., through bad cabinet-work, as well as by those persons—the terror of curators and collectors—who never learn that a naturalist's drawers should be handled as tenderly as a baby. A whole drawer-full of mounted shells may, by bad handling, be dismounted from their tablet at one shock. Each drawer should be covered with a sheet of glass that drops upon a rebate. The method of arranging "table-cases" in a gallery is a matter that requires consideration. If placed with their fronts facing a gangway, as shown in A (Fig. 13), it will be seen that those stopping to examine specimens impede the general traffic, and involves mutual discomfort to those stopping and those moving onwards; but if placed with their fronts across the room, with intervals of three to four feet between each case, as shown at B, such arrangement tends to draw off the traffic from the main gangway, and distributes the examining visitors over a gallery out of the way of the passing throng. Table-cases and drawers are usually devoted to objects that require mounting on slabs or in trays. Slabs are made of well-seasoned pine a quarter of an inch thick, and covered on both sides with tinted paper. Extinct species should be mounted on slabs covered with paper tinted to correspond with a geological scale of colours, such as the key to the Geological Survey Maps, or, better still, one formed of the various tinted covering papers cut to represent the relative thickness of strata and arranged in proper sequence, the names, thicknesses, etc., being printed in. Such a geological scale should be hung in every gallery as a key to the tinted papers on which recent and extinct species are fixed. The geographical regions may be indicated by coloured lines placed round the slab, in the same manner as adopted at the International Exhibition, previously described and represented at p. 212, Vol. III., keys for which should also be hung in each gallery. These slabs must be unwarpable. They are cut up in subdivisions of a full-sized gauged tablet, to allow of specimens being grouped, as shown at A (Fig. 15), to economise space and produce an orderly aspect. Trays are made of card or thin wood, and, like the slabs, are made so as to be exact subdivisions of a standard size, as shown by B (Fig. 15). For many years past I have employed a method that allows greater freedom in spacing out specimens than the tray system admits of, for it frequently happens that a specimen is just too large for a tray, so the next size must be taken, with consequent loss of space. My method consists of the employment of long ebonised fillets, fitted with three or more needle points, and short pieces of various lengths fitted with two needle points, shown at C (Fig. 15), so that if a drawer is to be arranged say for minerals, the bottom is first covered with a thick layer of fine cotton wool or velvet, the long slips are then hammered in at equal distances apart, and as each specimen is placed in position, a cross piece is pressed into the drawer bottom, so that each specimen receives the exact amount of space required for its proper display. This system will be understood by the aid of D (Fig. 16), which represents a drawer thus divided.

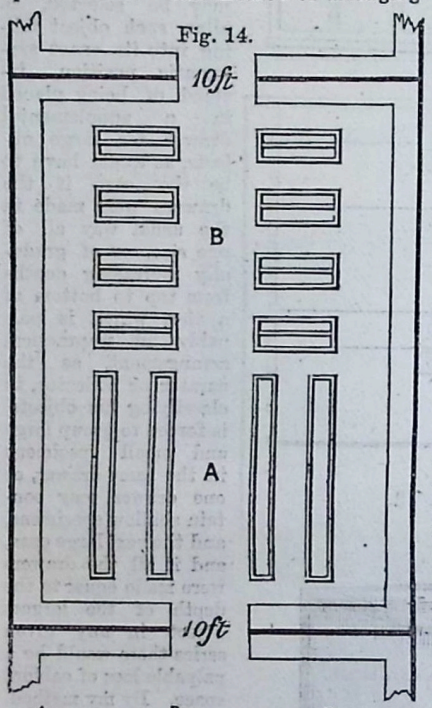


Fig. 14.

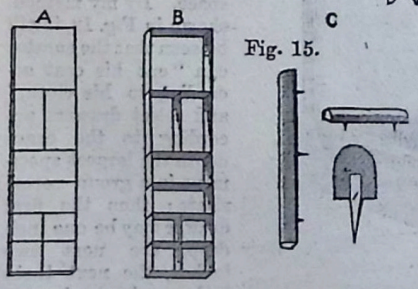


Fig. 15.

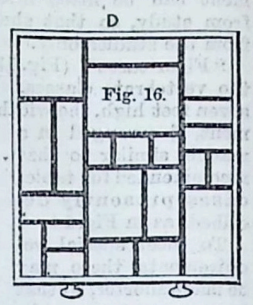


Fig. 16.

SEATS OF INDUSTRY.—XXXI.

BRISTOL (*continued*).

BY WILLIAM WATT WEBSTER.

EXTENSIVE improvements were effected in the harbour of Bristol in the first decade of the nineteenth century, by cutting a new channel for the river Avon—the old channel being converted into a graving-dock nearly three miles long, forming several graving-docks—and by enlarging the quay, which has now a length of 2,000 yards, extending along the banks of the Avon and the Frome. These works also included the construction of two capacious basins, the Cumberland and the Bathurst. The floating-dock covers an area of eighty-two acres, and the entire works cost £600,000. After a considerable decrease had taken place in the trade of the port, in consequence of the high rate of the port dues as compared with those of Liverpool, London, and other places, an Act of Parliament was procured in 1848 for transferring the management of the harbour from a company to the corporation, and the change was followed by a reduction of the rates which, combined with the provision of better accommodation, has caused a steady increase in the traffic.

The principal foreign imports of Bristol are sugar, molasses, rum, tea, and cocoa, the next most important being tobacco, timber, wine, brandy, tallow, fruit, wool, hemp, dye-stuffs, oils, saltpetre, and hides. The exports consist chiefly of the various articles manufactured in the city, with salt, iron, coal, and culm, in part the produce of the district. In 1863 the customs duties amounted to £1,150,599, and the total shipping that entered the port consisted of 6,495 vessels, of an aggregate burden of 494,511 tons, of which 1,780 were steamers representing 307,254 tons burden. There belonged to the port in the same year 380 sailing vessels and 41 steamers. Steam communication was established between Bristol and Ireland as early as 1826, and this was the first port in the kingdom that established a regular communication by steam with the United States, the first voyage having been performed by the *Great Western* steam-ship in 1838. This vessel was built at Bristol at a cost of £60,000, and the *Great Britain* and the ill-fated *Demerara* were also "cradled" there, the former costing £120,000. About 400 carpenters are at present employed in the ship-building yards of Bristol. The city has canal communication with the Severn and the Thames, and thence with all England. It is a terminus of the Great Western, of the Bristol and Gloucester, and of the Bristol and Exeter Railways, the former of which was constructed between 1834 and 1838, according to the plans of Isambard Kingdom Brunel, and was the first broad-gauge line in Great Britain. Numerous branch lines connect Bristol with all the principal towns in the west. The most important manufactures of the city are refined sugars, brass and copper wares, soap, glass bottles, crown and flint glass, chain cables, anchors, steam-engines and machinery, tobacco, earthenware, floor-cloth, brass wire pins, patent shot, sheet-lead, zinc, saltpetre, tin pipes, hats, drugs, colours, dyes, starch, bricks, British spirits, malt liquors, and soda. About 1,700 persons are employed at the Great Western cotton works, established in 1840, and the manufacture of woollens, worsted, paper, silk, linen, etc., occupies a large number of persons. Many of the iron foundries in the neighbourhood are on an extensive scale, and they

are increasing both in number and in size. Coal is found in abundance in the neighbourhood of Bristol, and large supplies are obtained from collieries in Gloucestershire.

During the latter half of the last century the population of Bristol would seem to have declined considerably, as the city, including the parish of Bedminster, only contained 66,922 inhabitants in 1801; in 1811 its population numbered 76,952; and in 1821, 95,758. Bristol proper had a population of 65,781 in 1851, but its suburban districts contained 116,094 inhabitants, giving a total population of 181,875. Within the municipal boundaries in that year there were 137,328 inhabitants. The parliamentary borough, which is conterminous with the municipal, extends over 4,674 acres, and in 1861 it comprised 23,590 houses inhabited by a population of 154,093, which, according to the census of 1871, have respectively increased to 27,547 houses and 182,527 inhabitants. Bristol has regularly returned two representatives to Parliament since the electoral franchise was first conferred on the city by Edward I., and the municipal government is vested in a mayor, sixteen aldermen, forty-eight town councillors, a Lord Lieutenant and Lord High Steward. The city is situated on the banks of the rivers Avon and Frome, about eight miles from the point where those rivers debouch into the Bristol Channel, and is on the borders of Gloucestershire and Somersetshire. It extends over seven hills and their intermediate valleys, and is surrounded by a beautiful and fertile district. A few ancient houses, constructed of wood and plaster, with the upper storeys projecting over narrow streets, are still to be found in the older quarters of the town near the river-side, but the greater part of the city consists of spacious streets and squares lined with well-built and substantial houses. Bristol is exceedingly rich in ecclesiastical antiquities. The remains of Roman encampments are to be seen at Clifton and Leigh, and traces of Druidical edifices have been discovered at Stoke and Stanton Drew. The interior of the venerable Cathedral in College Green has lately been restored, and its carvings and fittings renovated. Where the bishop's throne now stands, Bishop Butler, the author of the "Analogy," lies buried. Among the ancient monuments in Bristol Cathedral, the most interesting are those of Robert Fitzhardinge, and certain abbots, bishops, and crusaders; and among the modern, are Bacon's monument to Mrs. Draper (Sterne's "Eliza"), one to Lady Hesketh, the friend of Cowper, a monument to Southey by Bailey, and a fine figure of Charity by Chantrey. The elaborate Gothic gateway at the western end is considered the finest in England. St. Mary Redcliff, on the summit of a hill of the same name, is one of the best specimens of Gothic architecture in the kingdom. It contains several interesting brasses and monuments to Canynge and Admiral Penn, the father of the founder of Pennsylvania, and others, and its muniment room has been made famous in connection with the forgeries of Chatterton, "the marvellous boy" having alleged that he found the Rowley Poems and papers there. The altar-piece of this church was painted by Hogarth. There are forty-four places of worship in connection with the Church of England in Bristol, but the Dissenters are both numerous and influential: the Wesleyan communities have twenty-five chapels, the Independents about twenty, and other sects about thirty-five. Among the celebrated natives of Bristol are numbered William of Worcester the topographer, William Canynge, Sebastian Cabot, Edward Colston, Sir Wm. Draper, Thomas Chatterton, Robert Southey, Sir Thomas Lawrence the painter, Edward Hodges Bailey the sculptor; and the celebrities connected with the city include Samuel Taylor Coleridge, Robert Hall, and Sydney Smith, who was a Canon of Bristol Cathedral.

TECHNICAL DRAWING.—LXXVI.

DRAWING FOR CABINET-MAKERS.

LINEAR DRAWING.

In order that the student may be able to represent or design furniture or any other objects, he must carefully study the numerous and ever-varying combinations of lines, the geometrical methods of constructing rapidly and correctly the various forms required, and the system by which one view is projected from another, or from given dimensions.

These are some of the branches comprehended under the term "Linear Drawing;" and the object of the present course of lessons is to show their immediate application to the work of the cabinet-maker, whose peculiar work is the construction of furniture, etc.

The construction of the geometrical figures is fully demonstrated in "Practical Geometry applied to Linear Drawing," page 63, Vol. I. of The Technical Educator, and hence only such will be added as may be required for the immediate

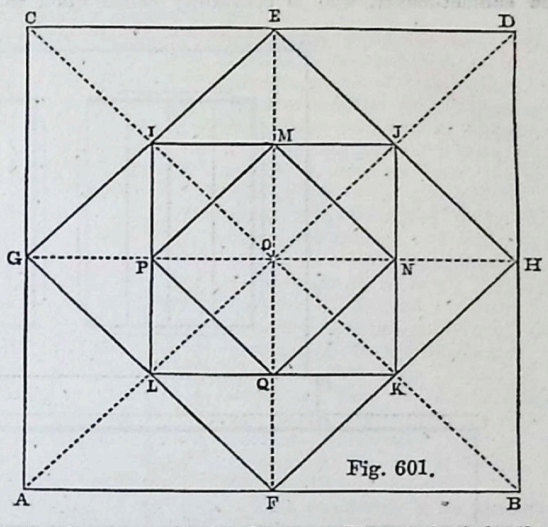


Fig. 601.

subject of any particular lesson. The student is therefore urged to work attentively through the lessons referred to, forming as they do the stepping-stones to all special branches of geometrical drawing.

The general principles of construction in wood, the methods of lengthening timber and joining boards, etc., have been given with numerous illustrations in "Drawing for Carpenters and Joiners;" and therefore these are not here repeated, in order

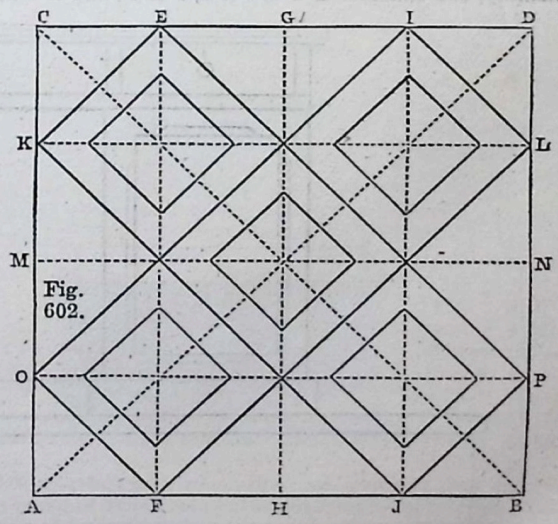


Fig. 602.

that special attention may be given to the Perspective of Furniture and Freehand Drawing, adapted to the present branch of industry.

The subject of this lesson is given with the view of affording the student practice in accurate combination of straight lines; and the forms are such as will at once show any imperfections, thus enabling the student to test his work as he goes on. These forms are in appearance very simple, but they are important, since, in the refinement required in the delineation of furniture, a single line out of place, be it ever so little, is liable to injure the entire drawing. The truth of this will be often exemplified as our lessons progress.

Fig. 601.—Construct the square A B D C. Draw diagonals A D and B C. Draw the lines E F and G H through the inter-

section (o) of the diagonals. Join F G, G E, E H, H F, thus constructing a square within A B C D.

The diagonals pass through the sides of this inner square in I J K L. Join these points, and another square parallel to the original one will be formed.

The lines E F, G H, cut through the sides of this square in M N Q P, and these points being joined, a fourth square will be formed, the sides of which will be parallel to F G E H.

The cabinet-maker, who is constantly called upon to cut numerous pieces of veneer into accurate forms, will find useful practice in this figure by drawing it on thick paper or card-board, and cutting it according to the lines. If correctly worked, the triangles G C E, E D H, H B F, and G A F should be equal to each other, and also to the four triangles G O E, E O H, H O F, and F O G. Consequently, these four triangles when placed together should form a square equal to F G E H.

Similarly, the triangles L G I, I E J, J H K, and K F L, are together equal to the square I J K L, and this same system will apply to the inner square.

Fig. 602.—This is another study of the same character as the last.

Draw the outer square A B D C, and divide it into sixteen equal squares by the lines E F, G H, I J, K L, M N, O P.

Join E P, K J, K E, and P J. Then the rectangle K E P J will consist of three equal squares placed upon and parallel to the diagonal B C. Again, join I O, F L, O F, and I L, and a similar rectangle parallel to the diagonal A D will be formed.

The inserted figure will then consist of four equal squares surrounding a fifth. The squares within these are drawn parallel to the others.

Fig. 603.—We now proceed to the delineation of a simple article of school furniture—viz., a master's pedestal table, with cupboard and drawers; and take the elevation facing the room first, being the simpler. The scale is ¾ inch to the foot.

Draw the ground-line, and the rostrum or platform on which the table stands. This platform is 9 inches high, and extends 1 foot on each side of the plinth of the table.

The body of the table is 4′ 6″ across, the plinth projecting ¾ inch all round, and the total height is 2′ 6″, out of which the thickness of the top occupies 1 inch, projecting 1½ inch on each side.

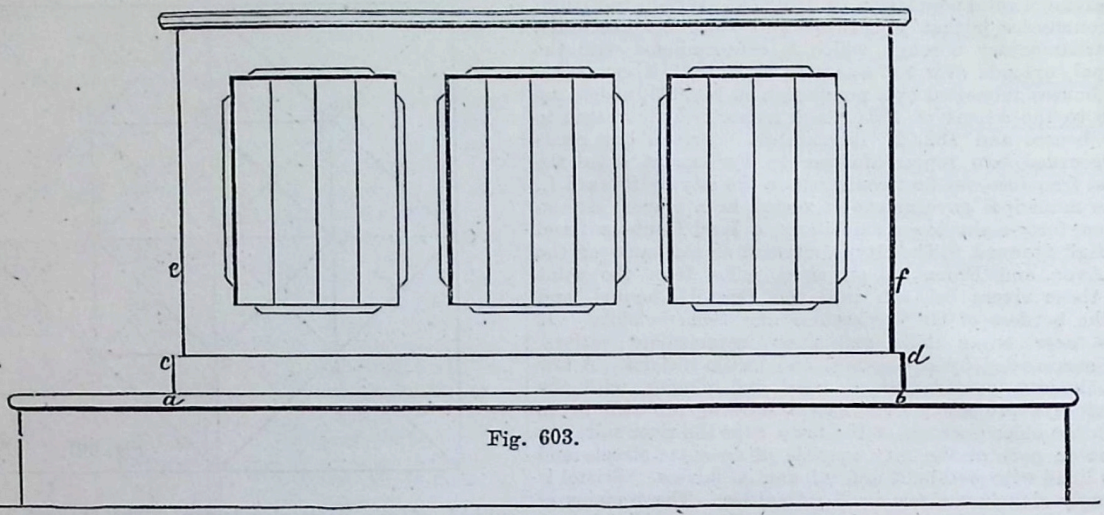


Fig. 603.

The front here presented is formed of three panels, the framing of which is 4 inches wide.

Proceed now to draw the plinth, commencing with the perpendiculars *a b*, and the horizontal *c d*. Next draw the perpendiculars *e f* at ¾ inch on each side within *a c* and *b d*, and then complete the general outline by drawing the top.

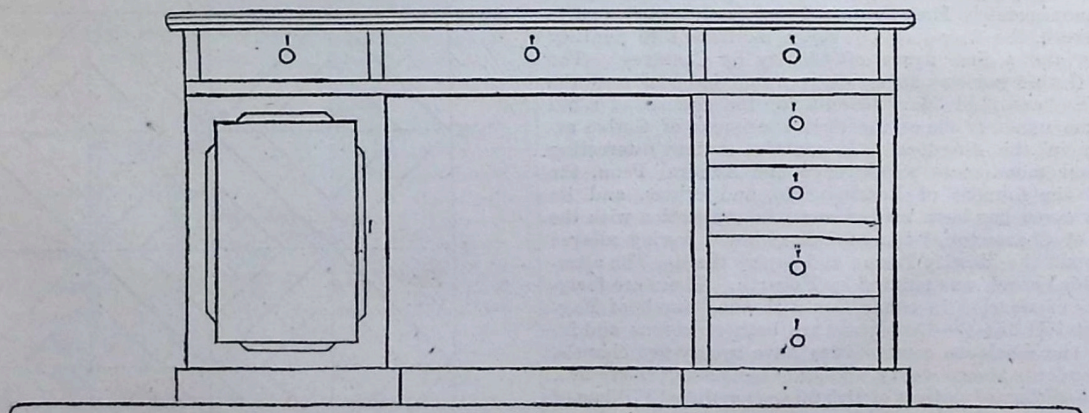


Fig. 604.

Draw the rectangles for the panels, the framing being 4 inches wide, chamfered at the edges up to 2 inches from the angles. This has the effect of lightening the appearance. The panels are made up of separate boards, the edges of which also are chamfered at their juncture, but too slightly to be shown in this illustration.

Fig. 604 is the true front of the same table, showing the pedestals, which are 1′ 3″ wide; the one contains a closet, and the other four drawers. The top of the table also contains three drawers, and is with the plate 6 inches deep. The general measurements are of course the same as in the other elevation, and the method of drawing this subject is precisely similar.

MINING AND QUARRYING.—XXVII.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

SHEET LEAD—PIPING—ADHESION OF LEAD AND TIN—ALLOYS—SHOT-MAKING—MASSICOT AND LITHARGE—PROPERTIES OF LITHARGE—REDUCTION OF LITHARGE—PEROXIDE OF LEAD.

THE large sheets of lead which are in such extensive use by plumbers for roofing and the making of water-tanks, are made in the following manner:—The pig lead is melted and cast in a rectangular mould, so as to form a large block of that shape, after which it is rolled out to the desired thickness. The first thing necessary for this purpose is a melting pot, large enough to contain eight or nine tons of lead at a time. The pot, A, Fig. 1, is made of iron, and hemispherical in form, having a pipe, B, issuing from the lower part of it, by which the molten metal is drawn off. Below the melting pot is a fire-grate, C; and before the lead is thrown in, the iron pot is heated up to redness; the charge is then introduced, and an iron hood, D, Fig. 2, which is suspended over the pot, and can be raised or lowered at pleasure, is let down upon it. The hood serves the double purpose of preventing the heat from being dissipated, and also the escape into the workshop of the hot gases from the melting lead, which would be injurious to the health of the workmen: these are carried off through a telescope pipe, E, Fig. 2, in the top, which is connected with the flue. The heat from the red-hot iron of the pot will be sufficient to melt the lead without keeping up the fire below, and it is not desirable to heat it beyond this point, or greater loss of metal will occur. When the lead is all melted it is skimmed, and then drawn off into the mould by the removal of an iron plug, F, in the pipe. The mould is entirely made of iron, the four sides being strongly bolted together and to the bottom plate, G. It is usually 6 or 7 feet across from side to side, and 8 or 9 inches deep. The bottom plate of the mould should be slightly concave in the centre, which will compensate the slight sinking of the surface in the middle of the casting during the process of cooling. Some care is necessary in letting the lead flow into the mould, as it comes out with great force, and is liable even, unless checked, to carry away the sides. Immediately the mould is filled, a wooden bar of the exact width of the mould is drawn over the surface of the liquid metal to remove all impurities, and this is repeated as often as may be necessary to keep the surface quite bright during the cooling. As soon as the lead has solidified the sides of the mould are removed, and the great block of lead is lifted off and deposited upon the rolling apparatus. This consists of a pair of very heavy iron rolls about 9 feet long, and nearly 2 feet in diameter, between which it is passed forwards and backwards a great number of times until it is gradually reduced to the required thickness; for this purpose the rolls are from time to time brought nearer and nearer together by means of adjusting screws. A series of wooden rollers on each side, which move freely, support the sheet of lead in a horizontal position while passing to and fro. The lead is generally slightly warm when the rolling commences, but that is not necessary to the success of the operation, and it is practically rolled cold.

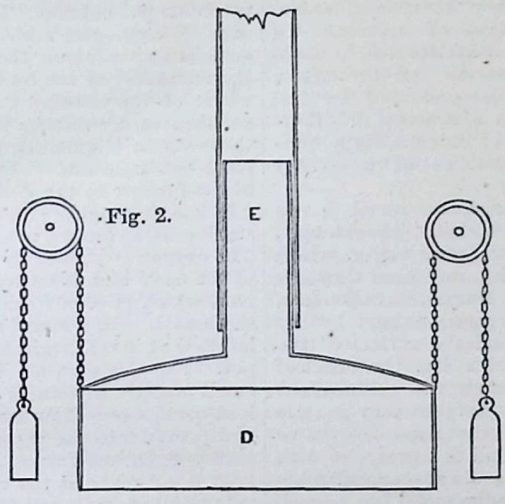


Fig. 2.

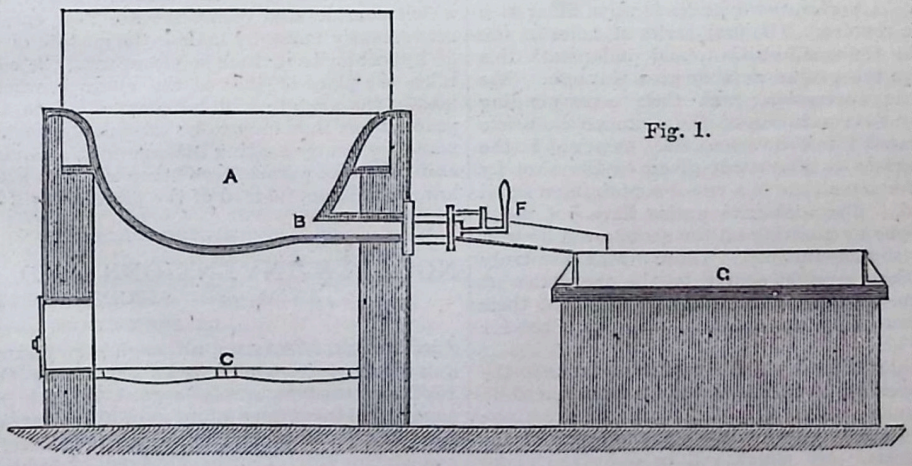


Fig. 1.

In addition to its domestic uses, which are sufficiently familiar, a considerable quantity of sheet lead, and that of the finest quality, is used in the construction of sulphuric acid chambers, as it is one of the few articles not affected by the oil of vitriol. Some idea of the quantity required for this purpose will be gathered from the article on sulphuric acid, in the series on "Chemistry applied to the Arts."

In lead pipes the soft desilverised lead is considered best, as it resists a greater pressure from within than the inferior qualities will; but many plumbers have a fancy for piping made of a harder metal, as the latter will better retain its circular form, and is therefore more easily manipulated. Antimony is even added purposely sometimes, for the sake of satisfying those who wish a hard pipe, though in other respects it is certainly not improved thereby. The lead is forced by great pressure through perforated dies corresponding to the respective sections of piping that may be desired, in the same way that the circular clay drainage pipes are made; by this means perfect uniformity will be secured throughout its whole length, and no seams will be required.

This operation is suggestive of one peculiar property of lead not hitherto mentioned, viz., that if the surfaces are thoroughly clean and bright, two pieces of lead can be perfectly united by mere pressure. In the same way, precipitated lead in the state of a fine powder may be compressed into a solid mass.

Tin-foil can be made to adhere to sheet lead in the same effectual manner by passing the two metals under heavy rollers; and this fact has been taken advantage of in the manufacture of the so-called patent metallic capsules, which are now very commonly used for protecting the corks of bottles.

Lead forms some alloys with other metals which are of value in the arts. Those with tin, forming solder of different kinds, have already been described; others will be treated subsequently under the headings of the respective metals with which the lead combines; but there is one compound of which lead is the chief ingredient, which forms an article of very much greater commercial importance than most persons would readily imagine. We refer to what is commonly known as shot metal.

Pure lead will not answer the purpose of the maker of small shot. In order to enable it to take a strictly spherical form, it has to be combined with a certain quantity of arsenic. The arsenide of lead, though harder than the pure metal when cold, is very liquid when melted, so as greatly to resemble mercury, the readiness of which to separate into small round globules is so well known. If the lead is of soft quality, about 0·3 per cent. of arsenic will suffice; but for a hard lead about 1 per cent. will be necessary. To ascertain when the lead has taken up the precise quantity required to make a good alloy requires

some little experience on the part of the manufacturer. The lead, to the quantity of two or three tons, is melted in a pot, and then the surface of the metal is strewn with a little powdered charcoal, immediately after which the arsenic, either in the form of arsenious acid or orpiment (the sulphide), is added, and briskly stirred in with the metal. The pot is then covered up, and after two or three hours the arsenic is reduced to the metallic state, and has entered into combination with the lead. During this process a good deal of the arsenic is unavoidably lost, so that even when dealing with good lead it is usual to add about 1 per cent. On uncovering the pot the surface of the metal will be found covered with a coating of oxide, which contains a considerable proportion of arsenic. To ascertain whether a suitable alloy has been formed, a little of the metal is taken out and allowed to fall through a perforated plate into water. The form presented by the grains will indicate whether there is a sufficiency or otherwise of arsenic, the composition which contains a right proportion of this substance yielding particles of a strictly spherical shape.

A satisfactory test having been attained, the metal is run into small ingots ready to be converted into shot. These ingots, for future use, are raised to the top of the shot tower, which should be upwards of 150 feet in height, and here they are remelted when required. The perforated frames, or cullenders, through which the molten metal has to pass, are kept hot by being surrounded with a charcoal fire, and the surface of the frames is dressed with a little oxide, which has the effect of allowing the metal to pass freely through the perforations without adhering to the edges. The apertures vary in size from 1-50th to 1-360th of an inch for the sizes known as numbers 0 to 9; but these will not be found to correspond with the size of the shot produced, which is always considerably larger than the perforation through which the metal has passed, as it widens out into the spherical form in falling. The smaller sizes are allowed to fall about 100 feet, but the larger about 150. At some of the shot towers on the Continent provision is made for a much greater fall than even this. At the bottom of the tower is a well filled with water to the depth of 5 or 6 feet, which receives the shot.

The desired quantity having thus been made, the shot is put upon a stove to dry. A perforated cylinder is then filled with the shot, and made to revolve. The first series of holes in the cylinder correspond to the smallest shot, and underneath this part is a box to receive the grains as they pass through. The larger sizes follow in succession, with their corresponding receptacles, so that by the revolution of the cylinder the whole mass of shot is separated into the various sizes required in the trade. The bright surface is afterwards given to the shot by their being agitated for some time in a vessel containing a small quantity of blacklead. The defective grains have yet to be separated, which is done by allowing all the shot to roll down a table which is very slightly inclined. Those which are truly spherical will run with a straight course to the receptacle at the lower end, but the defective ones will gradually find their way to the sides, where they are collected and put apart for remelting.

There are several salts of lead which are of importance in the arts. The oxide (protoxide, PbO) has already been referred to as one of the compounds produced in the course of smelting; but it will be more especially so when we come to speak of the separation of silver from lead, which will be described under the head of the more valuable metal. This compound is known both by the name of massicot and litharge, according to its colour, the former being more decidedly yellow than the latter. The chemical constitution appears to be the same in both cases, and the reddish tinge which litharge possesses is probably due to some difference in the molecular arrangement of the particles. It is a better article for ordinary purposes, as it is more stable than massicot, and resists better the action of the atmosphere. It is used as a pigment, and by the manufacturers of glass and earthenware. To the metallurgist it possesses properties of considerable value, as it forms fusible compounds with some of the metallic oxides which are infusible by themselves, and thus enables them to be readily separated from others. Those of copper and antimony are rendered fusible by a very small addition of litharge; those of tin, zinc, iron, titanium, manganese, and arsenic require a somewhat larger proportion. Sulphur is converted into sulphurous acid on heating it with an excess of litharge.

Notwithstanding the various useful purposes to which this oxide may be put, the quantity which is necessarily produced in the final processes for the separation of lead from silver, by cupellation, is so much in excess of what is required in trade, that the litharge has again to be reduced to the metallic state.

In many parts of the Continent this is done in blast furnaces; but in England preference is given to a large reverberatory furnace of ordinary construction, having a tap-hole at the lower end or side of the sole, with a pipe communicating with the receiving pot outside. The tap-hole should be protected by a dam of clay, over which the lead, when it has accumulated sufficiently, will run, the dam being only removed to draw off the remainder of the lead at the end of the operation, when the whole of the metal in the charge has been reduced. The work commences by raising the furnace to a red heat, and then throwing in a quantity of small coal of a quality which will leave but little ash. This must be spread evenly over the sole of the furnace to the depth of two or three inches. When the coal has thoroughly united, the litharge, mixed with some more small coal, is thrown in until the furnace is as full as convenient. The oxygen contained in the litharge combines with the carbon of the coal, and is evolved as carbonic acid, leaving the lead free, which is soon found to be flowing towards the bottom of the hearth. In a hour or two so much lead will have accumulated, that it will begin to flow over the dam into the receiving pot. For the next six hours fresh supplies of litharge and small coal are thrown in to keep the furnace full, and as the lead continues to flow into the pot, it is lifted out with ladles and poured into the pig moulds to cool. When the lead ceases to flow from the furnace, the dam is broken down, a greater heat is got up, and the residue well rabbled in order to separate the lead that will be mechanically mixed with the cinder, which should consist of little else than the ash from the coal. If the litharge, however, is impure, and contains the oxides of some of the other metals not uncommon in lead, some quantity of slag will be left at the close of the operation.

The peroxide of lead, PbO_2, acts the part of an acid in combining with the alkalies, calcium, barium, and other bases; but its principal use is in the manufacture of lucifer matches, in which considerable quantities are now employed. It may be conveniently made by boiling the acetate of lead in an excess of hypochlorite of lime solution, until the odour of acetic acid takes the place of that of the chlorine, when the whole of the lead in the acetate will be converted into the peroxide. The product has then only to be thoroughly washed. It can also be made by gently heating litharge with a mixture of the chlorate and nitrate of potash, care being taken to keep the temperature low, or minium, instead of the peroxide, will be the result.

NOTABLE INVENTIONS AND INVENTORS.

XXXII.—SIR SAMUEL MORLAND.

BY JOHN TIMBS.

Sir Samuel Morland, although born just upon two centuries and a half since, must not be left among forgotten inventors. He is entitled to special regard, for the glimpses which his mechanical inventions afford us of the science of the period, apart from his personal history, which is interesting. He was the son of the Rev. Thomas Morland, of Subhamstead-Bannister, near Reading, in Berkshire, and was born about the year 1625. He was educated at Winchester and Cambridge. He remained at the university for ten years, but never took a degree. Soon after leaving college we find him sent on the famous embassy to the Queen of Sweden, in company with Whitelocke and a retinue of other gentlemen. Whitelocke, in his Journal, calls him "a very civil man, and an excellent scholar." On his return, Morland became assistant to Thurloe, the secretary to Oliver Cromwell. He is said to have been privy to the plot usually known as Sir Richard Willis's Plot. In his chambers at Lincoln's Inn, Thurloe is reported to have discussed with Cromwell Willis's plot for seizing Charles II., early in 1659. In the same room sat Thurloe's assistant, young Morland, at his desk, apparently asleep, and whom Cromwell would have dispatched with his sword, had not Thurloe assured him that Morland had sat up two nights, and was certainly fast asleep.

He, however, divulged the plot to the king, and thus saved Charles's life. Birch relates the story in his Life of Thurloe; but it is not considered supported by proper evidence. Echard, in his History of England, produces a letter from Morland to Willis, dated March 10th, 1660, in which he expressly denies the above statement; but Morland's own testimony, in his Autobiography, is to the contrary; if he did write it at all, it was probably intended merely as a means of protection from the wrath of Sir Richard Willis.

Morland had already shown his genius for mechanical science. On the restoration of Charles he was made Master of Mechanics to His Majesty, who soon afterwards made him a gentleman of His Majesty's privy chamber.

It is now time to speak of his writings and mechanical inventions. From some correspondence between Morland and Dr. John Bell, it appears that Sir Samuel, as early as 1666, had intended to publish a work on the Quadrature of Curvilinear Spaces, and had actually proceeded to print a portion of it, when, by the advice of the latter, he was persuaded to lay it aside altogether. Morland not only yielded implicitly, but, in a letter written shortly afterwards, he furnishes arguments against some propositions of his own treatise. "I should desire," says he to Bell, "to bee altogether mute, and to submitt to your judgement in all things." Bell, in another place, informs us that two sheets of the work were actually printed.

It was about this time that Morland invented his arithmetical machine, which he mentions in a letter dated May 13th, 1666. He did not, however, publish an account of it before the year 1673, when, "by the importunity of his very good friends," it was made public. The little work in which it is described is illustrated with twelve plates, in which the different parts of the machine are exhibited. Its operations are conducted by means of dial-plates and small indices, movable with a steel pin. By these means the four fundamental rules of arithmetic are very readily worked, and to use the author's words, "without charging the memory, disturbing the mind, or exposing the operations to any uncertainty." His "Perpetual Almanack" is given at the end, which was often printed separately. One copy of Morland's little book, long in the possession of Professor Davies of Woolwich, contains a very beautiful portrait of the author, but with this exception, we have never seen an exemplar so distinguished.

The invention of the speaking trumpet in its present form is attributed to Morland, though it is warmly contested for Athanasius Kircher. The ancient contrivances of this kind resembled hearing rather than speaking trumpets. Some have considered the great horn described in an old manuscript in the Vatican Library, as having been used by Alexander the Great to assemble his army, to be the oldest speaking-trumpet on record; but the description does not state that Alexander *spoke* through the horn. Morland published the account of his useful instrument at London, in 1671, under the title of "A Description of the Tuba Stentorophonica, an instrument of excellent use, as well by sea as by land." In this rare tract, consisting of eight pages, he gives an account of the various experiments that he made before his instrument had attained a certain degree of perfection. The first trumpet that he constructed, "although," says Sir Samuel, "the invention had been long before digested in my thoughts," was made in glass in the year 1670, being about 2 feet 2 inches in length, the diameter of the greater end 11 inches, and that of the other end 2½ inches. "With this," he says, "I was heard speaking at a considerable distance by several persons, and found that it did very considerably multiply the voice." The next he made was of brass, about 4½ feet long, 12 inches in diameter at the large end, and only 2 inches at the small end, to which was affixed a mouthpiece, "made somewhat after the manner of bellows," to move with the mouth, and thereby prevent the escape of the breath. This was tried in St. James's Park, and rendered the voice audible at a distance of nearly half a mile. The third instrument was of copper, recurved in the form of a common trumpet; its total length was 16 feet 8 inches, the large end 19 inches and the small end 2 inches in diameter; with this the voice was heard about a mile and a half. After giving a description of some experiments with other trumpets, he enters into a philosophical description of the nature of sound, and the best form of speaking trumpet, which he leaves doubtful, and concludes with "an account of the manifold uses" of his instrument, which are very excusably exaggerated. He appears to have overrated the power of his trumpet, for, in his "Urim of Conscience," he says that he has no doubt but that it might be improved so as to carry the voice for the distance of ten miles. Yet Dr. Young records that at Gibraltar the human voice has been heard at a distance of ten miles. With the largest of Morland's trumpets, tried at Deal Castle, the voice was conducted a distance of between two and three miles over the sea. An advertisement prefixed to a French translation of Morland's treatise, published in London in 1671, states that Morland's tubes were sold by Moses Pitt, a bookseller in St. Paul's Churchyard, at the price of £2 5s. There is one of Morland's original trumpets, about six feet long, now preserved in Trinity College Library, Cambridge. It is in bad condition, and no one knew what it was till our time, when it was identified by a member of the college.

The invention excited such general interest at the time, as to make Butler say in "Hudibras:"—

> "I heard a formidable voice,
> Loud as the stentophonic noise."

The invention of the fire-engine has been claimed for Morland; but he was rather an improver than the inventor of that machine, which originated with Ctesibius, a distinguished Greek mechanician, who lived in the reign of Ptolemy Philadelphus. Hero, a pupil of Ctesibius, describes a sort of forcing pump with two cylinders, employed for extinguishing fires. Apollodorus, architect to the Emperor Trajan, has left a description of a machine consisting of leathern bottles, with pipes attached to them; when the bottle was squeezed, a jet of water flowed through the pipe, and was thus used to extinguish fires. Beckmann found, in the accounts of many of the German towns, entries for the cost of such machines: thus, in the accounts for the building of Augsburg for 1518, fire-engines are mentioned under the name of "instruments of fire," or "water-syringes." As early as 1590, Cyprian Lucar described a rude fire-engine, or squirt, which acted precisely on the principle of that instrument; Evelyn also mentions a fire-engine invented by Greatorex in 1656, which was ten years before he saw the "quench-fires" of Morland. In the vestry of the church of St. Dionis Backchurch, Fenchurch Street, London, are preserved four large syringes, which were formerly used for the extinction of fires; they are about 2 feet 2 inches long, and were attached by straps to the bodies of the firemen. At the present day a species of squirt is used among Oriental nations to extinguish fires. An old engraving purports that John Lofting, a merchant of London, was the inventor and patentee of the fire-engine; in one corner is represented the Monument, and in another the Royal Exchange; the engines are represented at work.

The principal objects of Morland's study were, however, water-engines, pumps, etc., which he carried to a high degree of perfection; his pumps brought water from Blackmore Park, near Winkfield, to the top of Windsor Castle. In 1675 he obtained a patent "for certain pumps and water-engines by him invented." In 1697, two years after his death, a tract by Sir Samuel was published at the expense of his son. It is entitled "Hydrostatics, or Instructions concerning Waterworks," and contains an account of his various methods of raising water, besides tables of square and cube roots. From the close of Joseph Morland's preface it appears that many of his father's works were left unpublished. There is also a treatise by Sir Samuel, in the Harleian collection of MSS., which is entitled "Élévation des Eaux, par toute sorte de Machines, reduite à la mesure, au poids, et à la balance. Présentée à sa Majesté très Chrétienne, 1683." At page 25 commences a very short tract on the steam-engine, entitled "The Principles of the New Force of Fire, invented by Chev. Morland in 1682, and presented to His most Christian Majesty, 1683," and these principles are explained as follows:—

"Water being converted into vapour by the force of fire, these vapours shortly require a larger space (about 2,000 times) than the water before occupied, and rather than be constantly confined, would split a cannon; but being duly regulated according to the rules of statics, and by science reduced to measure, weight, and balance, then they bear their load peacefully (like good horses), and thus become of great use to mankind, particularly for raising water, according to the following table, which shows the number of pounds that may be raised 1,800

times per hour to a height of 6 inches, by cylinders half filled with water, as well as the different diameters and depths of the said cylinders." Then follows his table of the depths of different sized cylinders. This evidently indicates a perfect knowledge of the subject; and, to his great credit also, let it not be forgotten that he has correctly stated the increase of volume which water occupies in a state of vapour, which must have been the result of experiment. His researches, however, seem to have had little influence on the progress of the practical application of steam (*Penny Cyclopædia*). It should be added that Morland does not indicate the form of the machine by which he proposed to render the force of steam a useful mover. It is, however, remarkable that at this early period, before experiments had been made on the expansion which water undergoes in evaporation, Morland should have given so near an approximation to the actual amount of that expansion. It can scarcely be supposed that such an estimate could be obtained by him otherwise than by experiments.

Among Morland's written works, according to Beughem, in his "Bibliographica Britannica," are "Articles and Rules for the better government of His Majesty's Forces by Land and Sea, during this present War." His "Doctrine of Interest, both Simple and Compound," published in 1679, has the tables very accurately calculated; but his "New Rule for the Equation of Payments" is erroneous. Another tract by Morland, consisting of four leaves, and entitled "The Count of Pagau's Method of Delineating all manner of Fortifications (Regular and Irregular) from the exterior Poligone, reduced to English Measure," etc., was published in 1672. The "Urim of Conscience," already mentioned, was written during Morland's blindness, and is a very singular piece of composition; it contains reflections on the fallen state and insignificance of man, and the uncertainty of life. Morland is said to have written a treatise on the barometer, which was answered by Lord North in another tract on the same subject. He is also said to have invented the capstan to heave up anchors; but he must be considered rather as an improver than the inventor of that machine. The same remark will apply to various other performances which have been elsewhere attributed to him.

Of more popular interest are the minor inventions of Morland, of which his abodes bore traces almost unto our time. Lysons, upon the authority of an enrolment in the Duchy of Cornwall Office, states that Sir Samuel Morland, in 1675, "obtained a lease of Vauxhall House, made it his residence, and considerably improved the premises." Aubrey tells us that some years before, Morland had built "a fine room at Vauxhall, anno 1667, the inside all of looking-glass, and fountains very pleasant to behold, which is much visited by strangers; it stands in the middle of the garden." And Mr. Bray, the historian of Surrey, was informed by one of the proprietors of Vauxhall Gardens, in 1813, of a circumstance which shows that the dwelling-house then connected with the garden once belonged to Sir Samuel Morland. From the back kitchen of the house a lead pump was removed, about 1794, bearing the mark—S.M. 1694. The room mentioned by Aubrey as having been erected by Morland, is believed to have stood where the orchestra was afterwards built; and grave old Mr. Bray hints at the probability of a room having been erected by Sir Samuel for the reception of Charles II., when he visited this place with his ladies. In the above house and grounds Morland formed a large collection of mechanical contrivances. He received his baronetcy in 1660, and subsequently had a pension of £400 settled upon him; but embarrassments in his affairs, owing to an imprudent marriage, obliged him to dispose of the house at Vauxhall. He afterwards removed to a house at Hammersmith, near the water-side, where he died December 30th of the following year (1695). Poverty and loss of sight compelled him to rely almost solely on the charity of Archbishop Tenison. In a letter dated March 5th, 1694, he returns him thanks for his kindness, "which was far greater," says Sir Samuel, "than such a poor wretch as I could ever hope for." This letter, written when he was blind, is a very curious relic, and is now preserved in the library at Lambeth Palace. John Evelyn, in his Diary, describes Morland when suffering under this accumulated load of misfortunes:—"25th October, 1695.—The Archbishop [Tenison] and myself went to Hammersmith, to visit Sir Samuel Morland, who was entirely blind, a very mortifying sight. He showed us his invention of writing, which was very ingenious, also his wooden calendar, which instructed him all by feeling, and other pretty and useful inventions of mills, pumps, etc.; and the pump he had erected that serves to water his garden, and to passengers, with an inscription, and brings from the filthy part of the Thames near it a most perfect and pure water. He had newly buried £200 worth of music-books, being, as he said, love-songs and vanity. He plays himself psalms and religious hymns on the theorbo." The inscription to which Evelyn refers is on a stone tablet fixed in the wall, and is as follows:—"Sir Samuel Morland's Well, the use of which he freely gives to all persons; hoping that none who shall come after him will adventure to incur God's displeasure by denying a cup of cold water (provided at another's cost, and not their own) to either neighbour, stranger, passenger, or poor thirsty beggar. July 8, 1695."

Morland constructed for himself a coach, with a movable kitchen in it, so fitted with clockwork machinery that he could broil steaks, roast a joint of meat, and make soup as he travelled along the road. The side-table in his dining-room was furnished with a large fountain of water; and every part of his house bore evidence of his ingenuity.

CAPITAL AND LABOUR.—III.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

THE WAGES OF LABOUR.

We have seen from the statements made in the preceding chapters that the true profits of capital are only wages under another name, and that these wages are due to the employer, because he superintends and directs other labour which is inferior or subordinate to his own. It is plain also that any contest between capitalist and labourer which has for its object—as either of the parties provokes or continues the contest—the advantage of one side at the expense of the other, is really a struggle between two classes of labourers, and that such a struggle could not occur except it were in the distribution of a stock or quantity, the several claimants of which base their demands on strictly analogous work. The amount of rent paid by an occupier of land, the rate of interest paid by a borrower, are not and cannot be objects of dispute, for they are settled upon considerations which are purely scientific, and therefore spontaneous in their origin, and precise in their quantity. A strike or a lock-out, in order to lower or heighten rent, to depress or exalt the rate of interest, would be a plain absurdity, to which no rational person would have recourse.

The wages of labour depend, exactly as every other article in value depends, on three causes. One of these is the demand for labour—*i.e.*, not labour in general, but the particular kind of labour. For since man must work in order to subsist, there always must be a demand, and a very energetic demand, for labour in general, or in the abstract. The second cause is the cost which has been incurred in order to produce the labourer—*i.e.*, to make him fit to carry on his work. The third is the probable duration of those powers, to the possession of which the labourer owes his power of producing something useful, and therefore of procuring employment. The labourer whose possession of such powers is temporary will as a rule obtain, relatively speaking, high wages during the time that his power lasts. For instance, I presume that the period in which a professional cricketer keeps his best strength, activity, and speed, is brief. The best-paid juvenile labour is that of a chorister in a cathedral. But the chorister's voice is sure to give way very soon after he has attained the best use of it. Those adults who are engaged in any dangerous or deadly trades, as, for instance, dry grinders, are paid at much higher rates than could be obtained for the skill which they possess, because those who are engaged in such a calling are notoriously short-lived. In short, the human body is a machine, which certainly wears out at some time or another, and may be deprived of those qualities which make it valuable at a very early date. The certain cessation and the possible arrest of those powers are risks of a less or more urgent kind, and must be provided against in just the same way that other risks are, by an extra payment.

At any given time, there may be too much of any given kind of labour in the market seeking for employment. In some callings this excess is chronic. Such is the case with needlewomen, with barristers, and perhaps with clergymen, the causes

of this excess being different. There are few employments open to women, and consequently those which can be followed are constantly overcrowded. The professions of the bar and the church are held in great esteem, and possess great occasional prizes. The first of these facts is practically an equivalent of wages; the second, owing to the natural disposition of mankind towards enterprise, and the general tendency of most persons to overvalue their abilities and their prospects, makes the callings attractive. And here it may be observed that self-esteem, which is odious in the individual, is, as a motive influencing men in the mass, one of the principal causes of social progress.

Sometimes again the cause is transitional. By this I mean that circumstances have arisen which render some kinds of labour unprofitable, and therefore depress the wages of those who ply the industry. At the present time such a state of things undoubtedly characterises the labour of the tailor and the shoemaker. Of late years work which used to be performed by hand is done by machinery. Now it is perfectly true that the substitution of mechanical labour for manual work is a gain to society; the substitution would never have occurred otherwise. A man who makes any process easier—and the motive which leads to the adoption of machinery is the design to make work easier—intends to sell the product of such work more cheaply, because in this way only can he get any advantage of increased sale in the general market. Generally, too, as the mass of society is benefited by the improvement, so the workman is not much harmed, since labour is in demand for the manufacture of the machines, and most industries are not of so rigid and special a kind as to disable the workman from seeking some similar employment. But there are cases where machinery annihilates an industry, or depresses it so seriously as to cause considerable distress to the workman. Such, as I have observed, is the case with the tailor and shoemaker. Similarly, I imagine, the art of photography has put an end to the calling, as a rule, of the miniature painter, and has induced similar effects on that of the engraver.

Lastly, the excess may be temporary. To this excess all callings whatsoever are liable, though in variable degree. In the winter months, the artisans employed in the building trades are ordinarily in excess. When the price of wool or cotton rises so high as to check the use of cloth manufactured from these materials, operatives in these callings are in excess. It is, however, superfluous to illustrate this kind of fact, for anybody who has had any experience whatever of social life could supply himself with instances.

We have thus been able to account for two of the causes which determine the rate of wages. These are the demand for the labour which the workman brings into the market, and the duration of those powers on which the value of labour depends. The remaining cause, the cost of producing the labourer, to which may be added the cost of maintaining the labourer, is, when the two other causes are accounted for, permanent, and governed by an invariable law. The law is, *If two persons of equal, or nearly equal natural capacity, are able to supply some labour which is in demand, the wages which each person will receive will be determined by the cost incurred in supplying the labourer, together with the charge which is necessary in order to enable the labourer to carry on his avocation.* To this law there is no exception.

My reader will see why I have used the expression, "of equal, or nearly equal capacity." There is, I am aware, an opinion that, in many callings at least, the capacities of men are equal, and that real differences in effectiveness are due to the fact that the ablest person has had the best education. If this be true, the case is covered by my definition, for greater cost has been incurred in preparing the individual for his calling. But if, as is certainly the case in some callings, and probably is in all, there are great differences of natural capacity or quickness, it is necessary to take account of such capacity, just as one does of the fertility which attaches to a particular field, or more notably still to some site for business premises. In some callings, natural capacity or genius is undeniably the primary cause of success, or, in economical language, of value. For example, the most mysterious of all natural gifts, that of the construction of music, has been developed at so early an age, and in so marked a manner, that no education can explain the phenomenon. It would be absurd to assign the genius of Mozart to training; and, in a kindred art, that of Shakespeare to careful instruction.

In order to enable us to deal with the effect of cost in producing the labourer on the rate of wages earned by the labourer, it will be convenient to explain the other element in the definition or law given above. Wages must include the cost of maintenance. No one could reckon the profit earned by a machine, unless he first deducted the cost of supplying the machine with the force necessary for its motion. So with the wages of labour. Now this cost varies with the labour. Take, for example, a physician in practice, a clerk in a counting-house, and an artisan. The first of these will be put to considerable cost in providing his home and his equipage, and in his manner of life. The second will need to have his home and his dress of such a kind as will probably be a considerable charge on his earnings. The last may be clad in very cheap garments, and does not need, as far as his habitation is concerned, any but the commonest and cheapest kind of lodging.

We now come to the most important constituent in determining the cost of labour, or the rate of wages, phrases which we will temporarily take to be synonymous. I say temporarily, for it is clear that low wages may mean dear labour, and high wages may mean cheap labour. If we merely gave the cost of their keep as the wages of a troop of unskilled and listless savages, as the condition of their performing the manual labour of a farm, we should find that our bargain would be a bad one. Contrariwise, if we were able to pick out the best farm workmen and artisans we might, even though we gave them wages which were considerably in excess of the average rate, we should find that the increased charge would be more than counterbalanced by an increased gain.

For the purpose of argument, however, we must assume that the labour is average in point of effectiveness, and that therefore the wages paid correspond to the cost incurred in producing that on which the labourer is engaged. We have taken into consideration what the charge is which must be incurred by the labourer himself, in order that he may be able to work at all; in other words, we have accounted for the cost of his maintenance. Besides this, we have assumed that the supply of labour is not in excess of the demands of the public; or, to vary the phrase, we are considering that labour only, the quantity of which is ordinarily equal to the use which the general wants of society can find for the service which is tendered. The remainder of the workman's wages is exactly proportioned to the cost or difficulty which has been incurred in order to provide him at all. If this cost has been high, the wages paid will be high; if, on the contrary, it is low, the wages will be low. It makes no difference how the cost has been diminished, whether it be brought about by the fact that the workman has been brought up and trained at the public expense, or has been cheaply taught by his relatives and friends. Similarly it makes no difference whether the workman has been made scarce or costly because it is hard to train him, or because some artificial expedients have been adopted in order to make his service expensive. The illustration of these several means by which labour may be made cheap or expensive will form the subject of this paper, and will amply prove my contention.

Some workmen are brought up and trained at the public expense, both for the highest and for the commonest callings. Thus, out of a feeling of religion or humanity, the practice of modern society will not allow any destitute person to starve; and least of all, those who are destitute without any fault of their own—such as children who have lost their parents, or have parents who are unwilling or unable to support them. Such children are maintained and educated by public charity, the funds necessary for the process being compulsorily levied on the occupiers of property. Now these children, if they are brought up, as they must be brought up, to compete for employment against others, reduce the average wages of all against whom they compete, by the cost of their bringing up. Similarly, the principle operates in the case of those who are bred up to professions, or assisted in entering such professions, by the funds which are derived from educational endowments. Long ago, Adam Smith pointed out that the scanty incomes obtained by clergymen in his time were, in part at least, to be ascribed to the fact that in a great measure the cost of their maintenance and education was defrayed from the endowments of the two great English universities. Again, there

is hardly a country in the world where the remuneration of the teacher is, on the whole—particularly in those branches of learning which require long and careful preparation—lower than it is in England. The reason referred to already is the explanation of this fact. The endowments in aid of the work done by the teacher are very great in this country, amounting, in the aggregate to several millions of annual income, and devoted partly to preparing the teacher for his calling, partly to assisting him with an income after he has entered on his calling. It is probable that half the students in Oxford and Cambridge are assisted largely in the cost of their education, and everybody knows how numerous, and in some cases how wealthy, endowed grammar-schools are. These permanent contributions to the education and incomes of teachers lower the sums which are paid to those who do not share in them.

Again, if the skill needed for any calling is cheaply imparted, the labour, however skilful it may be, is always scantily remunerated. A good agricultural labourer knows more than any other workman does. His knowledge is the growth of ages of accumulated skill. It is astonishing to think how many difficult operations he is competent to perform. None but they who have tried it can conceive how difficult it is to drive a long straight furrow, of uniform depth, with a plough. It is really a high art, and needs long and careful teaching. But this is only one among many kinds of skill which a good farm hand possesses. Still he is the worst-paid labourer in the country, and it is a wonder how he can live. The rule, however, which has been given above will explain the reason. He costs very little to bring up. From his earliest years he is set to farm work, and so earns his poor living. As soon as he has strength to do so, he follows his father to the plough, and gets instructed in his calling. His eye and hand are continually being educated in the numerous operations which he will be called on to perform, and which he will perform well. If, on the other hand, he was debarred from earning his living till he reached, or nearly reached, the maturity of his powers, his wages would be far higher than they are under his present circumstances.

I will now deal with such instances as exhibit the contrary phenomena. There are some callings in which the opportunity for earning a living is only accorded after a protracted delay. Such a calling, for example, is that of a barrister. The mere education of a barrister is not very expensive. At any rate, it is far less costly than that of many other callings. But the chance of success is doubtful; and, except in very rare cases, the fact of success is very slowly realised. Many men do not obtain a moderate income in this profession till they have reached middle life. As a consequence their training is peculiarly costly, for, in accordance with the rule given above, the successful advocate is remunerated not only for his own outlay, but for the outlay of those who are unsuccessful. The same facts are found in those occupations where great personal reputation is needed in order to command remuneration. Such a reputation is naturally of slow growth, and is accorded only after great scrutiny on the part of those who repose trust in the individual. It is no easy matter for a man to acquire fame as a physician, or as an attorney.

The same circumstances surround those callings in which the cost of producing the labourer are artificially enhanced, and the same consequences ensue. It was with a design to obtain larger wages for equal amounts of skill and labour that the custom of requiring an apprenticeship was first established, and has since been maintained. It is to prevent the flooding of a calling with a host of competing labourers, and thereby the lowering of wages in that calling, that combinations of artisans have carefully regulated the conditions under which persons can be admitted into this or that kind of so-called skilled labour. No business is easier to learn than that of a bricklayer. It is not supposed that there is any great labour required in order to fit a man to become a compositor. Were these callings thrown open to any one who might choose to qualify himself in any irregular manner, there is little doubt that many could do so, and that by these means the rate of wages in these and many analogous callings would be greatly lowered.

Wages, then, may be lowered either because the workman is assisted in obtaining the skill necessary for carrying on his calling, or because he learns the business in which he is engaged with little cost, and at an early period. On the other hand, they may be heightened because the period at which the workman earns his living is usually late in his life, and because his training is therefore costly; or the workman may, by some expedient, be debarred from learning his craft easily, or taking to it in early youth. In all these cases the rule laid down above is illustrated—that the rate of wages conforms to the cost of producing the labourer.

SEATS OF INDUSTRY.—XXXII.

LEITH.

BY WILLIAM WATT WEBSTER.

Leith is the principal port on the eastern coast of Scotland, and until quite recently it was the sole harbour of Edinburgh, the capital of the northern division of the kingdom, of which it may be said to be a commercial and manufacturing suburb. The greater part of Leith is built on the level ground on both sides of a small river called the Water of Leith, near its confluence with the Frith of Forth, and is about two miles distant from Edinburgh, but an unbroken line of houses now connects Leith with the Scottish metropolis. This proximity to Edinburgh has powerfully influenced the fortunes of Leith. It is a striking instance of a port that has had, and still has, to contend against natural disadvantages of a formidable description; but which, nevertheless, has contrived to maintain, to a great extent, the commercial pre-eminence it early acquired among the sea-coast towns of Scotland.

In the twelfth century Leith was already a town of some note. The earliest reference to it that has been discovered occurs in the charter of Holyrood Abbey, which was founded by David I. in 1128. It is there termed *Inverleith*, and, so far as is known, this is the original name of the town. In 1313 the shipping in the port of Leith was burned by the English, and in 1329 the magistrates of Edinburgh obtained a charter from King Robert Bruce, granting them the harbour and mills of Leith. Subsequently the authorities of the capital purchased all the other rights and privileges of the town from Logan of Restalrig, and its municipal government and harbour administration remained in their hands until the passing of the Scottish Burgh Reform Act in 1833, which conferred on Leith the right of electing its own magistrates and councillors, and of managing its own municipal affairs. It was visited again by an English fleet in 1410, and its shipping destroyed. Before the close of the fifteenth century, we find the magistrates of Edinburgh abusing the extraordinary powers placed in their hands by Robert I., for in 1485 they passed an Act ordaining that no merchant of Edinburgh should presume to enter into partnership with an inhabitant of Leith under the penalty of forty shillings Scots, and the loss of the freedom of the city. The subjection of Leith to Edinburgh naturally excited bad feeling between the inhabitants of the two towns, and the jealousy survived for some time after Leith acquired its independence. A bridge was built over the river in 1493 by Robert Bellenden, Abbot of Holyrood House, which was used till 1788, when the first drawbridge was erected. In 1544 Leith was almost entirely destroyed, and its whole shipping was carried off by an English fleet under the command of the Earl of Hertford; and five years later a body of French troops sent to assist Mary of Guise, the Queen Regent, in the attempt she made to suppress the Reformation in Scotland, took possession of the town. Leith was besieged and captured in 1560, by the combined forces of Queen Elizabeth and the Lords of the Congregation, the leaders of the Scottish Protestants. The Solemn League and Covenant was subscribed by many of the inhabitants in 1643; and in 1649 the town suffered from a plague, which proved fatal to 2,000 out of the 4,000 inhabitants it then contained. After the defeat of the Scottish army by Cromwell at Dunbar, in 1650, Leith was occupied by an English force, under the command of Major-General Lambert, while the Protector took possession of Edinburgh; and shortly afterwards General Monk took charge of Leith. This last-mentioned officer induced several English families to settle in the town, and to their influence a large portion of the commercial enterprise subsequently manifested by its inhabitants is ascribed. During Cromwell's occupation of Leith, the inhabitants petitioned him to relieve them from "the sad and most grievous oppressions" they lay under from the magistrates of Edinburgh, but without effect. Cromwell repaired the fortifications of the town, and erected a citadel with five bastions at North

Leith, for the purpose of defending the harbour. A large portion of these works were demolished at the Restoration. Races were introduced at Leith in the reign of Charles II. The citadel was held for a short time by the Pretender in 1715. In 1779 the American privateer officer, Paul Jones, appeared in the Forth with three armed ships, and created a great panic by threatening to destroy all the vessels in the Frith and harbour; and about 1783 a battery of nine guns was erected to the west of the site of the citadel, for the protection of the port. This battery was afterwards enlarged into a fort and garrisoned by the Royal Artillery, Leith being the head-quarters in Scotland of that branch of the military service. At one period Leith was walled in on the land side.

Within the last one hundred and fifty years very large sums of money, partly supplied by the Government, have been spent on the improvement of the port. In 1720 a dock was formed on the east side of the river, and in 1777 a small quay, called the Custom-house Quay, was built. In the year 1800 a magnificent suite of wet-docks was planned, and by 1817 two were completed, each measuring 750 feet in length by 300 feet in width, and having a united area of about 10 acres. In 1831 an addition of 500 yards was made to the Old or East Pier, which, however, still gave but 17 feet of water over the bar at its mouth at high spring tides, so that no vessel above 400 tons could enter the harbour without lightening. Between 1848 and 1855, more gigantic works were constructed, including the formation of the Victoria Dock, which is equal in size to any of the others; the erection of the New or Western Pier and low-water landing slip; and the extension of the Eastern Pier 1,000 feet seawards. Vessels of 2,000 tons burden can be accommodated in the Victoria Dock. By the extension of the piers, which approach each other at their extremities, leaving an entrance of 250 feet, ships are enabled to get into smooth water in easterly gales sooner than formerly. The harbour stretches out upwards of a mile into the Firth of Forth, and has a depth of from 20 to 25 feet at high water. A line of railway has been laid on the Western Pier, so that vessels may use it either in discharging the whole of their cargoes, or in lightening in order that they may proceed up to the inner port. These piers are unsurpassed, and in addition to other useful purposes, they furnish the citizens with a healthful and pleasant promenade. Lighthouses are erected on both piers. The aggregate length of the quays is 8,400 feet, and they, together with the docks, are lined with extensive warehouses, furnished with powerful cranes and other machinery for loading and discharging, and have a line of railway connecting them with the Leith terminus of the Edinburgh, Perth, and Dundee line, and also with the North British Railway. There are six graving docks at Leith, one of which is 490 feet long by 80 feet broad at the coping, and 24 feet deep on the sill at spring tides. But, notwithstanding all that has been done, Leith is not by any means a thoroughly efficient port. Commenting on the enormous outlay that has been made on the harbour of Leith, and the results that have been obtained by it, Mr. J. R. M'Culloch says:—"The object in carrying out the piers was to form a harbour which at their extremity should have water sufficient to enable vessels to come to the landing stage at all times of the tide. But this object has not been fully attained; and though it had, we should have been inclined to regard the outlay upon it as little better than thrown away. The truth is, the docks and the new harbour at Leith are entirely misplaced! Instead of being where they are, the docks should have been constructed at Trinity or Granton, about three-fourths of a mile or one mile from Leith, being, however, nearer to it than the extremity of the new pier." A harbour has been formed at Granton by the Duke of Buccleuch, consisting of a pier built on the most approved principle, in the shape of the letter T, having harbours and landing stages on both sides, and projecting into the sea about 1,700 feet, and the duke has also constructed a breakwater. Previous to 1866, Granton was a creek of the port of Leith, but in that year it was made an independent port.

The manufactures of Leith are numerous and considerable, but it is to its commerce that the town chiefly owes its importance. In 1692 the shipping belonging to the port consisted of 29 ships, with an aggregate burden of 1,702 tons. In 1850 the shipping registered at Leith numbered 210 of which 187 were sailing vessels aggregating 19,490 tons burden, and 23 were steamers aggregating 3,790 tons; while in the same year 2,349 sailing vessels, representing 164,000 tons burden, and 807 steamers representing 191,060 tons entered the port, and 1,203 sailing vessels, with a total burden of 98,872 tons, and 800 steamers, with a total burden of 190,687 tons, cleared the port. In 1855 the number of vessels belonging to the port amounted to 168 sailing ships of an aggregate of 19,067 tons, besides 25 steamers of an aggregate of 6,326 tons. The total value of the exports in 1859 amounted to £872,673, and the Customs revenue of the port in the same year amounted to £572,872. In 1862, 4,761 vessels, with a total burden of 930,670 tons, entered and cleared the port. Among the principal imports of 1862 were 481,530 qrs. wheat, 213,538 qrs. barley; 47,075 qrs. oats; 51,547 qrs. beans and pease; 11,746 qrs. Indian corn; 86,192 sacks and barrels of flour; 58,352 loads of timber; 14,604 tons of guano; and wine and tobacco also figured largely in the returns. The registered shipping in 1864 consisted of 136 sailing vessels of a total burden of 23,614 tons, and 63 steamers of 13,984 tons burden. The Customs duties on goods imported into Leith in 1867 amounted to £607,264, and there belonged to the port in that year 84 sailing vessels of 50 tons and upwards, and 58 of less than 50 tons, the aggregate burden of the former being 22,479 tons, and of the latter 1,798 tons, and 52 large and 21 small steamers having a joint burden of 20,859 tons. The proportion of steam vessels to sailing ships, it will be observed, steadily and rapidly increases. Leith has an extensive foreign and colonial trade with Russia, Holland, Denmark, Sweden, Germany, the Levant, the East and West Indies, America, China, and Australia; but it is with the northern countries of Europe, and especially with the towns on the shores of the Baltic, that most business is done. It has frequent steam communications with St. Petersburg, Copenhagen, Rotterdam, Hamburg, Dantzig, etc. The home trade of Leith is also very large, and steamers ply constantly between it and London, Liverpool, Hull, Newcastle, Greenock, Glasgow, Aberdeen, Wick, Lerwick, and other British ports. The chief exports of the town are iron, hardware, machinery, coal, cottons, linen, silks, woollens, and haberdashery. Its principal manufactures consist of ropes, canvas, soap, candles, colours, paints, leather, bottles, and glass, the latter industry having been, it is believed, introduced into Leith by English settlers in the time of Cromwell. It also possesses several large ship-building yards, a sugar-refinery, meat-preserving and fish-curing establishments, several breweries, a distillery, extensive saw mills, cooperages, and iron foundries, and a number of very extensive flour mills.

Previous to the passing of the Reform Bill in 1832, Leith had no representative in Parliament, but since that time it has sent one member to the House of Commons. The local government is vested in a Provost, who bears the ancient title of "Admiral of Leith," four bailies, a treasurer, and councillors. The courts held by the magistrates are designated the Admiral and Bailie Courts. In 1851 the district of Leith, embracing Leith, Musselburgh, and Portobello, contained a population numbering 30,919, which in 1861 had increased to 45,417, and is still growing. On the whole, Leith has a mean and dirty appearance, and in the older quarters of the town the streets are narrow and inconvenient, and the houses closely built and dilapidated; but many of the more modern streets, especially in the neighbourhood of the "Links," an open down on the south-east, are wide thoroughfares, lined with handsome houses. The part of Leith which stands on the north-west side of the river is known as North Leith, and that on the opposite side as South Leith. It is in the former that the principal places of business, warehouses, and even residences of the merchants are situated. Among the public buildings the most noteworthy are the Town Hall and Court House, built in 1828, where the Borough and Sheriff Courts are held; the Custom House, a Grecian structure with pediment and columns; and the Trinity House, built in 1817, in place of the edifice erected in 1555, which is adorned with a large and important picture by David Scott. The Female Asylum for Incurables, which was given to the town by Sir John Gladstone, the Premier's father and a native of Leith, deserves mention. This noted Liverpool merchant also built a church called St. Thomas, in his native town, which he handed over to the General Assembly of the Established Kirk of Scotland. The Rev. John Home, the author of "Douglas," and the solitary dramatic writer of any note that Scotland has produced, and Hugh Arnot, the historian of Edinburgh, were natives of Leith.

TECHNICAL DRAWING.—LXXVII.

DRAWING FOR CABINET MAKERS (*continued*).

The first subject of this lesson (Fig. 605) is a portion of a piece of furniture called a *Secretaire*, adapted either for a library, parlour, or bedroom. It consists of two heights; the upper one being fitted with shelves to contain a small selection of books, whilst the lower case contains drawers. The upper portion of this lower case is not, however, a drawer as appears externally, but is provided with a hinged flap, which folds down on its lower edge so as to form a writing-board; and behind this is the nest of pigeon-holes shown in the present example.

In this nest the pigeon-holes are ranged above the drawers, the space in the centre being closed by a small door, opened and shut by a secret contrivance; and behind this are other pigeon-holes and drawers for cash or private papers.

The door is hung on pivots placed horizontally at about $\frac{3}{8}$ inch from the top, and is so arranged that on being pressed inward at the top it yields backward and tilts out below, affording a hold by which it is raised parallel to the cross-cheeks, and thrust into them.

In commencing to copy this example, draw the perpendiculars *a* and *b*, and the horizontals *c e* and *d f*, thus constructing the rectangle *c d e f*, which is the boundary of the nest of pigeon-holes. Next draw the pilasters and cornice of the whole case, and the horizontal line *g h*. The rectangle *d f g h* is the edge of the writing-flap, which is here represented as turned down at right angles to the front of the secretaire, in order fully to expose the pigeon-holes. Draw the inner line of the nest, representing the thickness of the wood, and then the horizontal line *i j* dividing the pigeon-holes from the drawers. The rectangle *c e f d* is now divided horizontally into two others. In the lower portion set off on each side the upright cheeks of the middle compartment *k l*, rule the horizontal lines, and divide the left and right spaces into drawers.

Now carefully divide the upper compartment into twelve equal parts, and on each side of the points of division set off half the thickness of the wood forming the sides of the pigeon-holes; across these draw the springing-line for the arches, and on this set off the centres from which these are to be struck. The rest of the subject will now be easily followed from the example.

The next subject (Fig. 606) is the front elevation of a dwarf mahogany book-case, drawn to the scale of 1 inch to the foot.*

In commencing to copy this object, having drawn the ground-line and the external perpendiculars for the sides of the case, draw the two horizontal lines representing the thickness of the top.

Next draw the bottom line, and then the inner edges of the pilasters. This may be followed by the narrow fillet, which is the bottom of the transverse member, representing an architrave supporting the top, but in reality forming a portion of the main framing of the case, as will be seen by the section, Fig. 607.

The shelves are now to be drawn; but on this head no instructions will be required. The feet are to be commenced by a central perpendicular, crossed by a horizontal dividing the two portions. On this line are situated the centres from which, with radius extending to A, the upper curves are struck; the centres for the lower curves are on the ground-line, at the distance marked B.

Fig. 607 is the section on A B. From this it will be seen that the top does not depend only on the general carcase of the case, for, as is seen in the elevation, the whole front is open, whilst the section shows that the back affords but little support, since it consists merely of a framed panel, screwed into the sides, the cross-pieces, and the bottom. The main support of the top is obtained from two stout pieces of timber, the section of which is shown at *c* and *d*. These are at their ends dovetailed into the tops of the sides; the one is screwed to the front ledge, whilst the framing of the back is screwed (as already described) to the other. The object of this additional strength in the top of the case is to provide for heavy objects, such as air-pumps, microscopes, and other philosophical instruments, being placed upon it.

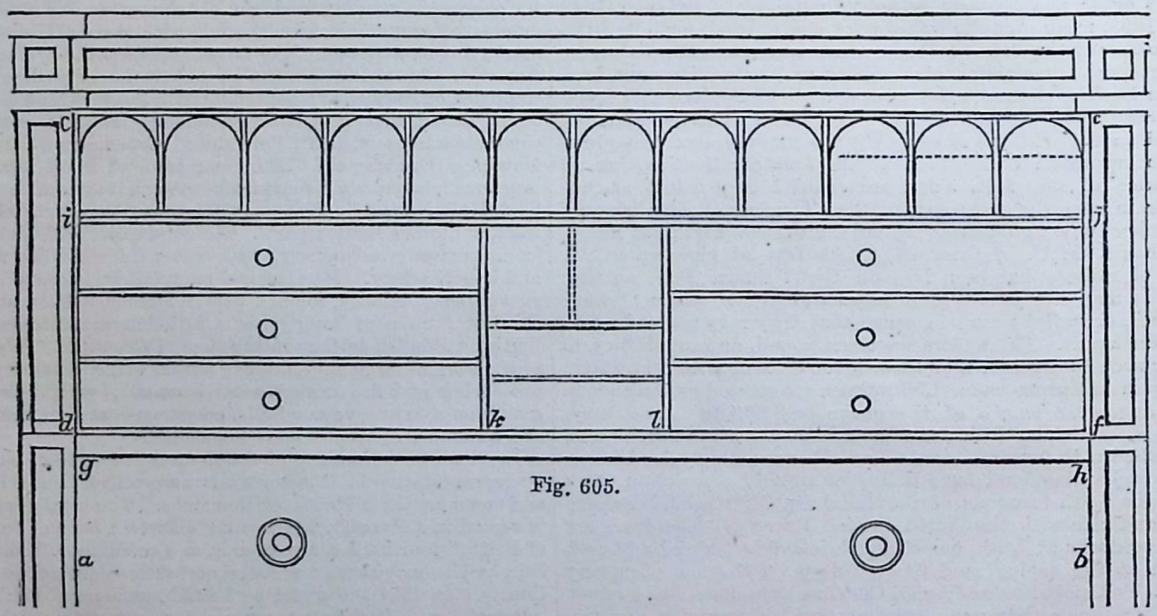


Fig. 605.

The inside of the book-case is provided with movable shelves resting on racks. These consist of a pair of toothed slips, *e f*, (about) $1\frac{1}{4}$ inch broad by $\frac{3}{8}$ inch thick, exactly similar to, and equidistant from, each other, glued along the insides of the walls of the case. Cross-ledges, *g g*, of the same thickness, and bearing the shelves, *h h*, are fitted between the slips, so as to rest on the teeth of the slips, with which, when pressed in, they become flush, and the heights of the shelves may be changed as required by moving the cross-ledges.

In simple book-shelves this is sometimes accomplished by cutting saw-like grooves in the sides, and bevelling the ends of the shelves, which thus slide in and out. This could not be applied in the present case, since the front of the pilasters projects beyond the mere thickness of the sides; they are therefore put in obliquely, and then dropped down on to the ledges, a small piece being taken out of each corner to allow space for the slips.

Another method is by wooden pins placed in holes, ranged in pairs at different heights in the sides. This is not generally satisfactory, since the pins have a tendency to fall out, causing the trouble of removing the books in order to replace them.

The method of drawing the section is precisely similar to that

* For the method of constructing a plain scale the student is referred to the Technical Educator, Vol. I., page 38.

pursued in regard to the elevation, and therefore it is not deemed necessary to give any further directions. It will be observed that the top projects more at the back than in the front. This is to allow for the skirting near the floor, so that the top may be brought close up to the wall.

Fig. 608 is the front elevation of a small mahogany writing-table with drawers and desk-top. Fig. 609 is the end elevation, showing the method by which the top is raised or lowered. The upper surface of the body of the table, and the under surface of the top, are each sunk about $\frac{3}{8}$ inch to allow of the support lying flat between them when the top is flat. This support works on toothed slips or racks, so that the slant of the top may be adjusted as necessary, at will.

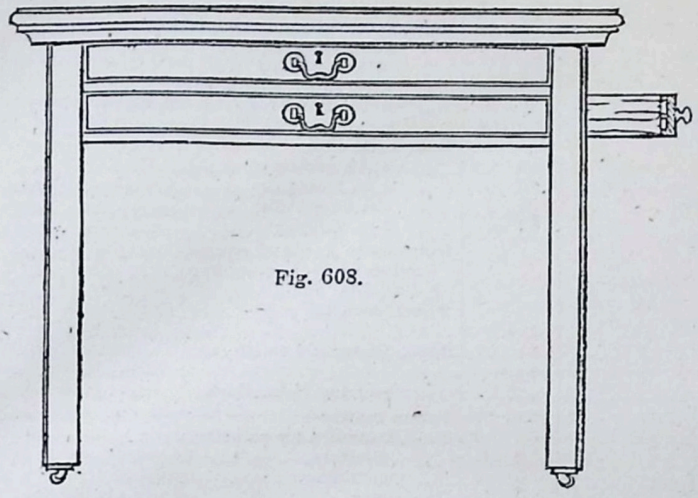


Fig. 608.

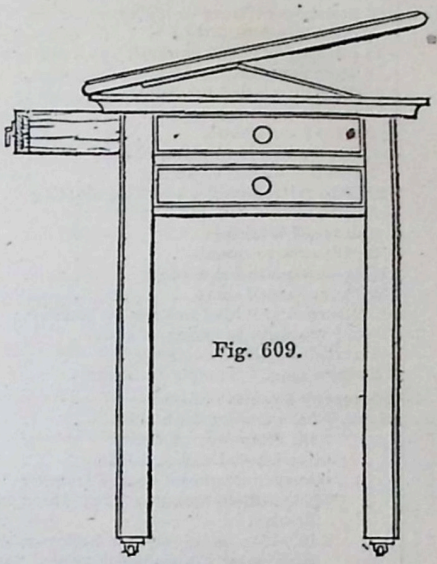


Fig. 609.

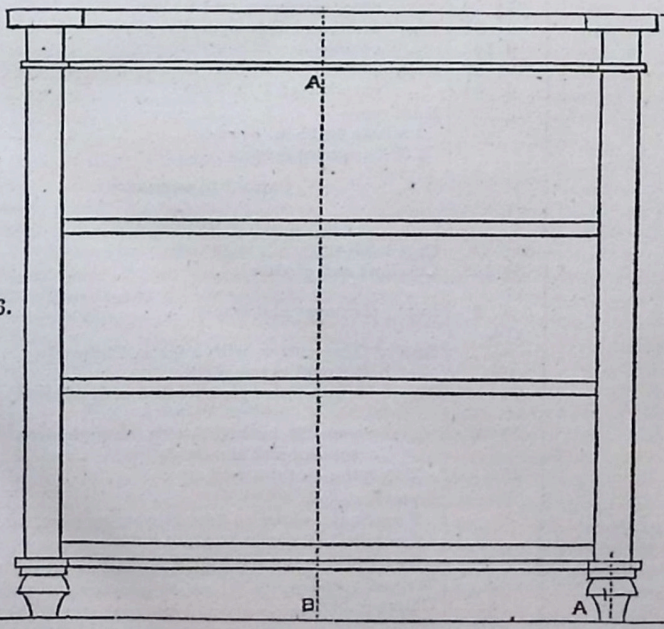


Fig. 606.

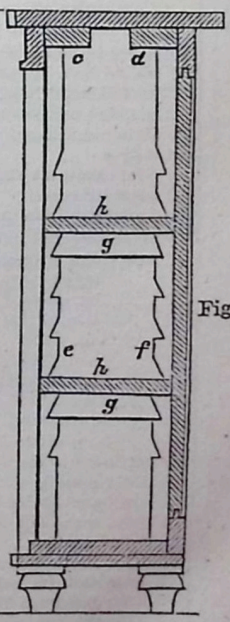


Fig. 607.

The top drawer in the front, and the lower drawer in each end, are made to open, the others being necessarily sham drawers; for it will be clear that the space which would be required for a bottom drawer in the front is occupied by the drawers in the end, and the space which would be wanted for the top drawers in the ends is taken up by the top drawer in the front. This is plainly visible in the two figures.

The outer edges of the legs are rounded off and beaded. In commencing these subjects draw the ground-line, and another above it, at a height equal to that of the castors. Next draw the perpendiculars for the legs; and it may here be mentioned that it will save time and add to the accuracy if both the views be proceeded with simultaneously, as the heights can thus be ruled with the same horizontal lines.

At a little distance, therefore, from the front, draw the perpendiculars for the legs of the end elevation. Having done this, next draw the horizontals for the framing, the top, and drawers, and unite those of the top by curves for the mouldings. Of course, in the end elevation the top is not formed by horizontal lines, and in copying the example the angle should be measured by the method shown in "Linear Drawing," so that the inclination in the copy may correspond with that of the original. The handles, castors, etc., do not call for any special instructions. The handles in the drawer and false drawer in the front of the writing-table are made of brass, and turn on pins passing through sockets in the circular plates, from each of which a screw projects, which is passed through the woodwork of the drawer, and fastened within by a nut. Handles of this kind are useful, as they admit of an easy application of the key. When solid knobs are used instead of a swing-handle, as in the side drawer which has no hole, and which therefore requires only one knob, two should be used, one on either side of the lock in the centre.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIX.

BY E. WYNDHAM TARN, M.A.

BILL OF QUANTITIES (*continued*).

JOINER AND IRONMONGER.

		Numbers in deal—
		63 housings of flyers to string
		6 ditto winders, ditto
		15 ditto balusters to handrail
		4 ditto steps into newell
		30 ditto dovetailed for balusters
		6 rounded corners to shelf
		2 ditto 2 in. dresser
		2 Ogee cut ends to stiles of sash
		2 tongued angles to string
		10 ditto mitred angles to 15 in. skirting
		8 ditto mitres to 9 in. ditto
		3 dovetail blockings
		2 pendants to newell
		15 1½-in. square balusters
		30 1½-in. turned ditto
		15 returned moulded nosings to treads
		15 cut brackets to string of stairs
		1 curtail scroll end to step
		2 elbow caps. 2 soffits to boxings
FT.		Mahogany French polished—
2	2	Supl., ¾-in. wrought both sides
11	5	,, 1 in. ditto seat and riser
6	2	,, ditto beaded flap and frame
34	6	,, ditto moulded and square framing
25	6	,, 1¼ in. ditto counter top, glued and blocked
24	6	,, 2 in. ditto astragal and hollow folding sash door, diminished stiles, lower panels moulded and bead flush
66	6	,, 2¼ in. lamb's-tongue shop sash
17	6	,, ditto, ditto, circular
3	6	Run, moulded nosing
7	0	,, ½ in. skirting, 4 in. wide
15	0	,, 3 in. moulded handrail
3	0	,, ditto, writhe
18	0	,, beaded door frame, 3″ × 3″
3	0	,, wrought and chamfered fillet
6	0	,, mortise clamp
6	0	,, heading joint
		Numbers in mahogany—
		1 dished hole in seat of water-closet
		1 beaded hand-hole, ditto
		2 rounded corners to skirting
		1 fitting and hanging flap to counter
		4 mitres
		1 ¾-in. quadrant shelf, 9″ × 9″, on fillets
		1 handrail scroll
		30 housings in handrail
		Ironmongery and fixing—
		3 pair 1½-in. wrought iron butts and back-flap hinges
		2 ,, 2-in. ditto
		3 ,, 2½-in. ditto
		1 ,, 3-in. ditto
		1 ,, 3½-in. ditto
		1 ,, 1½-in. brass butts and gilt head screws
		3 ,, 2-in. ditto
		1 ,, 4-in. ditto
		1 ,, 5-in. ditto
		2 cupboard locks
		1 iron-rimmed lock, and brass furniture
		2 6-in. mortice locks, and china ditto
		1 10-in. drawback lock
		1 patent latch
		2 brass escutcheons
		3 brass sash fastenings
		2 ditto casement ditto
		1 wrought-iron shutter-bar, 3 feet long, and plates
		1 brass rack chain fastening
		3 ,, knob turnbuckle
		1 ,, thumbscrew and plates
		2 ,, hook and eye
		2 ,, 10-in. barrel bolt
		3 handrail screws
		2 screw bolts to newell
		1 screw nut and joint to newell cap
		1 cast-iron newell
		2 ditto shelf brackets
		6 japanned cloak pins
		2 pair china finger plates
		4 ebony drawer knobs
		8 brass sunk flush rings
		3 dozen brass hooks
		2 pair swing centres
		4 brass handles
		Carried to summary . . £

PLASTERER.

YDS.	FT.	
		Portland cement, with three parts sand—
53	6	Supl., render plain work on brick and jointed
27	4	,, ditto pilasters
37	11	,, ditto moulding
205	6	,, ditto hearths and floors
38	3	,, dubbing out for extra thickness
FT.	IN.	
44	0	Run, arris edge
66	0	,, 4½-in. reveals
70	0	,, 3-in. moulding
25	6	,, chamfered edge
52	0	,, 7-in. skirting
		Numbers in Portland cement—
		4 mitres to 15-in. moulding
		8 ditto 3-in. ditto
		10 brackets, 12″ × 6″
YDS.		
44	0	Supl., render and rough cast
SQRS.		
3¾		,, pugging 1½-in. thick
YDS.	FT.	Parian cement—
57	0	Supl., trowelled for painting
0	21	,, pilasters
0	6	,, moulding
0	42	Run, quirk
0	45	,, skirting, 9-in. high with 3-in. moulding
		Number—
		6 mitres to ditto
		Plaster—
57	0	Supl., render and set
57	0	,, ditto float and set
27¾	0	,, lath, plaster, and set
49¾	0	,, ditto float and set
77½	0	,, stop, claircolle, and whiten
0	81	,, ditto, and distemper, two tints to cornice
0	162	,, cornice
0	87	Run, quirk
0	54	,, enrichment 6 in. wide
		Numbers—
		12 mitres to 18-in. cornice
		2 36-in. centre flowers
		Carried to summary . . £

SMITH AND BELL-HANGER.

CWT.	LB.	
		Cast iron—
36	109	Columns and girders
FT.		
3	9	Supl., casement and frame
YDS.		
8½		Run of Ogee gutter, with clips and brackets
9½		,, half round eaves, ditto
16		,, 3-in. rain-water pipe, jointed with red lead
FT.	IN.	
10	6	,, balcony, 21 in. high, with wrought-iron top-rail and standards
25	0	,, coping on 9-in. wall
		Numbers—
		2 heads and shoes to 3-in. rain-water pipe
		2 nozzles. 2 angles to Ogee gutter
		2 coal plates and hooks. 4 air-bricks
LB.		Wrought iron—
144		Chimney bars
217		Guard bars
137½		Shelf
93¾		Rail
433		Bars
15		Lead for running
FT.		
15	0	Supl., ½-in. wrought-iron door and frame, with hinges, lock, and brass knob
10	0	,, ⅛-in. sheet-iron linings to panels, and drilling holes therein
		Numbers—
		40 points to 1-in. bars

40 holes in ½-in. rail
1 frame and door to copper
30 ½-in. bolts, 15 in. long, with heads, nuts, and screws.
2 ditto, 12 in. long, ditto
2 1-in. ditto, 12 feet long, ditto
1 4 ft. 6 in. kitchener
1 copper, weight 14 lb
2 36-in. register stoves, steel front
4 30-in. ditto, Berlin black

BELL-HANGER.

Number—
10 bells hung complete, with cranks, tubing, springs, back-carriage, pendulums, etc.
4 ornamental lever pulls
1 brass knob pull and plate
1 ditto slide ditto.

Carried to summary . . £

PLUMBER.

CWT.	LB.	
45	0	Milled lead, and laying on roofs
2	1	Ditto, ditto, gutter
5	70	Ditto, ditto, hips
1	101	Ditto, ditto, step flashing
2	89	Ditto, ditto, cistern
17	6	Run, soldered angle to cistern
15	0	,, close nailing, with copper nails
12	0	,, ¾-in. strong pipe and joints
45	0	,, 1-in. ditto
35	0	,, 1¼-in. ditto
16	0	,, 1½-in. ditto
32	0	,, 5-in. soil ditto

Numbers—
2 solder joints to ¾-in. pipe
2 ditto, 1-in. ditto
2 ditto, 1¼-in. ditto
2 ditto, 1½-in. ditto
2 1¼-in. brass washer and waste
1 1¼-in. trumpet standing waste-pipe, 27 in. long
1 service-box soldered to cistern
1 brass grating ditto
1 ¾-in. ball-cock and copper ball
1 ditto bib-cock
1 1-in. stop-cock
1 D-trap
1 syphon-trap in 1½-in. pipe
1 water-closet apparatus, with blue and white basin, brass handle, etc.
1 2½-in. force-pump
1 bend to 5-in. soil pipe

Carried to summary . . £

ZINC-WORKER.

FT.		
126	0	Supl., 25 oz. zinc, laid on flats
24	0	Run, 4-in. eaves gutter and fixing
30	0	,, 2½-in. rain-water pipe, and ditto

Numbers—
2 octagon heads to rain-water pipe
2 shoes ditto
2 nozzles. 4 stopped ends to 4-in. gutter

Carried to summary . . £

GAS-FITTER.

FT.	IN.	
55	0	Run, 1-in. wrought iron welded tubing
30	0	,, ½-in. tin ditto

Numbers—
5 short pieces of 1-in. iron tubing
3 bends ditto
2 tees ditto
1 cross ditto.
1 connecting piece, ditto
1 1-in. stop-cock
8 ½-in. union joints
4 12-in. plain brackets
2 24-in. double ditto
1 pendant with hydraulic joint
1 5-light chandelier, ditto

Carried to summary . . £

GLAZIER.

FT.	IN.	
62	3	Supl., glazing with seconds crown, in squares, 14″ × 10″
36	0	,, ditto, with best crown, in squares 18″ × 12″
19	6	,, ditto, with best 26 oz. British sheet, in squares 39″ × 18″
19	6	,, polishing to ditto
73	6	,, glazing, with ½-in. best British plate, in squares 7 ft. by 3 ft. 6 in.
10	0	,, ditto, with ¼-in. ditto, in squares 48″ × 15″
13	6	,, ditto, rough plate.
24	6	,, bending plate glass
96	0	,, glazing in lead quarries with tinted cathedral, copper ties soldered on, and cementing to stonework
6	0	,, hacking out old glass

Numbers—
8 dozen squares cleaned
4 glass tiles, 20″ × 10″

Carried to summary . . £

PAINTER AND DECORATOR.

YDS.		
8⅓		Supl., knotting, stopping, priming, and 3 oils
31		,, ditto, 4 oils
4		,, ditto, to skylight, ditto
96		,, 4 oils, and flat ash green to plaster
10½		,, grained and twice varnished.
FT.	IN.	
16	0	Run, knotting, priming, and 2 oils, shelf edge
34	0	,, ditto, 3 oils, cutting to treads of stairs
30	0	,, ditto, ditto, strings, ditto
240	0	,, ditto, 4 oils skirting
40	0	,, ditto, ditto, staff bead
96	0	,, grained and twice varnished, skirting

Numbers—
3 shutter bars, 3 oils
4 sash frames, both sides, 6 ft. by 4 ft., 4 oils
2 ditto, ditto, 8 ft. by 5 ft. 6 in. ditto
8 doz. small squares, ditto
2 ditto large ditto, ditto
2 small casements, ditto
4 stone chimney-pieces, 5 oils

YDS.		
4⅓		Supl., staining deal, sizing, and twice varnishing
40		,, distemper, two tints
IN.		
102		Run, 4-in. letters, gold and shaded.
FT.	IN.	
48	0	,, 1-in. moulding gilt

Carried to summary . . £

PAPER-HANGER.

YDS.	
47	Supl., canvas lining
36	Run, border
FT.	
130	,, 1-in. gold moulding, fixed with needle points

Numbers—
8 pieces of paper, value 1d. per yard, hung, including preparing and sizing walls
11 ditto, 2d. ditto
13 ditto, 6d. ditto
15 ditto, marbled, 3d. per yard, hung in blocks, lined, sized, and varnished
39 ditto, hanging lining paper, preparing and sizing walls

Carried to summary . . £

SUMMARY.

Excavator and Well-sinker
Bricklayer
Tiler and Slater
Mason
Carpenter
Joiner and Ironmonger
Plasterer
Smith and Bell-hanger
Plumber
Zinc-worker
Gas-fitter
Glazier
Painter and Decorator
Paper-hanger

Total . . . £

SHIP-BUILDING.—XVIII.

BY W. H. WHITE,
Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DECKS OF SHIPS (*concluded*).

THE framing of decks occupies a position, in relation to what we have termed the "deck-flat," similar to that occupied by the frames of ordinary ships in relation to the skin planking or plating. Consequently the transverse beams do not aid the flat in resisting longitudinal bending strains, although they are most important aids to the maintenance of transverse form. There have, however, only been very few cases in which transverse deck framing has been given up in favour of other arrangements. Having to act independently, it becomes most important that the deck-flats should be made strong, in order that they may lend efficient help to the skin and the longitudinal pieces of the framing, in their resistance to longitudinal bending strains. This fact has long been recognised by writers on the theory of ship-building, but it has only within the last few years had any considerable influence on practice; and probably its general recognition at the present time is as much due to the necessity for much greater strength in the long ships now built as it is to any other cause. Wood ships were expected to display some amount of weakness in the upper works after having served for a moderate time, even when the best possible arrangements of the deck-flats had been made; and in the earlier iron ships the decks were little, if anything, stronger than those of wood ships, advantage not being taken of the superior qualities of the new material. This neglect led in some cases to serious, if not fatal, accidents. Such accidents, and evidences of weakness in numerous other cases, have so fully shown the necessity for giving a strong top flange to the ship considered as a girder, that builders now take steps to supply such a flange in iron ships; and we shall afterwards illustrate some of their plans. In many recent wood ships, too, a similar object has been aimed at, and to some extent attained; but before describing this modern practice it will be desirable to glance at the usual arrangement of the deck-flat in ordinary wood ships.

Wood ships with wood beams have their deck-flats formed by planking laid upon and fastened to the beams, as shown in Fig. 54, p. 36; hence the term "deck-flat" is commonly used instead of "deck-planking," although we have given it a wider meaning. In combining and fastening the strakes of deck-planking, care is taken similar to that described for the skin-planking. The strakes are almost always placed longitudinally, crossing the beams at right angles. Their butts are placed upon the beams, and shifted so that three passing strakes may come between consecutive butts on the same beam; the shift of butts is consequently identical with that for outside planking, shown in Fig. 27 (Vol. III., p. 256). The fastenings are also somewhat similarly arranged, only in the deck-planking they consist of nails or dumps (short bolts) driven into, not through the beams. With broad planks, double fastening is used in each beam; with narrower planks, double and single fastening is sometimes employed; single fastening is rarely used. Each of the butts is generally secured by two bolts driven into the beams.

We have already described how the deck-flat is bounded by the thin water-way, near the ship's side; and it will suffice to add here that towards the bow and stern, where the decks narrow rapidly, the strakes of plank lying nearest the side are ended successively. Nearer the middle of the deck, and stretching along by the sides of the principal hatchways, there are usually fitted several thicker and stronger strakes of planking, termed "binding strakes." These planks are carefully fastened to the beams (by scoring or dowelling), and running throughout the whole length of the ship, they form a valuable longitudinal tie. The remainder of the deck planking is usually of uniform thickness.

Where the hatchways occur special arrangements are required. The side-framing of these openings is formed, as said before, by longitudinal carlings let down between the beams, which form the foremost and aftermost boundaries of the hatchways. Upon these carlings "coamings" are fitted to enclose two sides of the hatchways, and upon the beams other pieces, named "headledges," of the same depth as the coamings, are secured to complete the enclosure. The inner binding strakes of the deck-flat fit against the sides of the coamings; and between the headledges of adjacent hatchways, the deck-plank has to be fitted in short lengths. In fact, this latter portion of the flat must be regarded chiefly as forming part of the deck, considered as a watertight platform; and it does not contribute much to the structural strength. It is impossible, however, to enter into detail further, and attention must next be directed to the arrangements of the deck-flat in a wood ship with iron beams, such as is illustrated by Fig. 55, p. 36.

The main portion of the flat in such cases consists of deck-planking worked directly upon the beams, and arranged with similar care to that of ordinary wood ships. In order to add to the strength of the deck, especially against hogging strains, the stringer-plate s is worked upon the beam-ends; and being carefully butt-strapped, as well as fastened to the beams and to the side, it forms a most valuable longitudinal tie. It, of course, helps the deck-planking somewhat also against sagging strains tending to compress the upper part of the ship; but this is of less importance than its assistance against hogging strains, because the butted planks at any cross section—amounting to no less than one-fourth of the total number of strakes—are effective against compressive strains, but almost useless against tensile strains. Experience with vessels constructed on this plan has proved that the addition of the stringer-plate is a very considerable improvement; and the fact is becoming generally recognised, although the use of such iron strengthenings is not yet common. From the sketch it will be obvious that these desirable results have been obtained without sacrificing simplicity of workmanship, or encroaching upon the internal space; in fact, as regards the first-named feature, the use of iron beams and stringers has made it possible to greatly simplify as well as improve the beam-end connections. The stringer-plates, it must be added, run throughout the whole length of the ship, and those on opposite sides of a deck are brought together and secured to each other at the bow and stern. By this simple arrangement the necessary connection is secured between the two sides of the ship, and all the elaborate devices of "ekings," "deck-hooks," "transoms," etc., required in a ship with wood beams are dispensed with. This is a matter of some importance, and it will not be out of place to illustrate it more fully. The ordinary practice in ships having beam-end connections similar to those shown in Fig. 54, p. 36, is to stop the shelf-pieces a little short of the bow and stern, the ends being rounded off just beyond the second or third beam from each extremity. For the remainder of the length a longitudinal timber named an "eking" is secured to the ship's side, the upper surface being well with the upper surface of the beams, and forming a support for the deck-planks. Close to the stem the eking is associated with a massive timber "breast-hook" or "deck-hook," which is bolted to and strongly connects the opposite sides; and right aft a corresponding timber known as a "transom" is fitted. In many cases the connection thus made is strengthened by large iron "crutches," forged so as to fit upon the inner surfaces of the deck-hooks and transoms, and bolted through them and the timbers of the frame. Contrasting this elaborate arrangement with the simple stringer arrangement possible with iron beams, it will be seen that the advantages attaching to the later plan are considerable.

The deck-planking in cases such as Fig. 55, p. 36, is secured to the beam-flanges by nut-and-screw bolts; but in wake of the stringer-plate the fastenings of the planks should be brought away from the beams, and placed in the intermediate spaces. By this means the beam-flanges are only weakened by the holes for the rivets securing the stringer-plate, and the deck-planks are enabled to aid the stringer against buckling under compressive strains. Sometimes the flanges of the beams are too narrow to receive the bolts securing the butts of the planks, and then it becomes necessary to rivet a small butt-plate to the beam under the butt.

Passing on to ordinary iron ships, we meet with an arrangement of deck-planking precisely similar to that just described, associated with some description of iron strengthenings. The most common forms of the latter are stringer-plates on the beam-ends, longitudinal tie-plates on each side of the principal hatchways, and diagonal tie-plates stretching from side to side between the hatchways. It is most desirable that the stringer-plates should be directly secured to the outside plating, with which they have to act in resisting bending strains, and to

accomplish this involves some trouble on some of the decks. For example, Fig. 56, p. 37, illustrates the kind of connection that would be employed on the main or lower deck of an iron ship. Notches have to be cut out of the stringer-plate in wake of the reversed frames, in order that it may be "fitted home" to the outside plating, and the connection of the two is made by means of short pieces of angle-iron. A continuous stringer angle-iron is fitted inside the reversed frames, in order to strengthen the connection with the side. This plan answers every purpose as long as it is not required to make the stringer watertight between the frames; but when the reverse is true, which is not commonly the case, other means are adopted. One of the simplest plans for securing watertightness is to fit short pieces of plate in the spaces between the frames, and to secure them by forged "staple" angle-irons, fitting accurately against the frames and plating; the stringer-plate proper running along inside the frames, and being secured to the short pieces of plates either by a lap-joint, or by a flush-joint with a covering edge strip.

The frames commonly end beneath the upper deck stringer-plate, so that it can be secured to the outside plating, or "sheer-strake," without difficulty, by a continuous angle-iron. Such a connection is obviously of greater importance on the upper deck than it is on either of the others, because failure is most likely to begin at the upper part if it occurs at all. In cases where exceptional strength is considered necessary, it is usual to obtain it by increasing the breadth and thickness of the stringer-plate, and by doubling the sheer-strake; and a similar course is often followed when ships display signs of weakness. Longitudinal and diagonal tie-plates are also fitted upon the upper decks of iron merchant ships to give greater strength—the former being intended to act with the stringer-plate in resisting bending strains, and the latter to lend some aid against such strains, in addition to preventing any "racking" in the deck. There is no doubt that these tie-plates are useful when so fitted; but it is questionable whether the material thus disposed might not be better placed in the form of an addition to the stringer-plate. This point has been much discussed by ship-builders, particularly as regards the use of the diagonal ties; and now Lloyd's Rules permit the disuse of diagonal ties, provided a certain additional strength is given to the stringers. The longitudinal ties at the sides of the hatchways are, however, still made compulsory by the Rules, although strong arguments may be advanced in favour of their disuse. Supposing, for example, that the iron used in these longitudinal ties were added to the stringer-plate, it would be intimately associated with, instead of being distant from, the skin-plating with which it is required to act; and, moreover, the stringer so formed would be likely to form in itself a more efficient longitudinal strengthening than is formed by the widely-separated stringer and tie-plate, which may or may not act jointly. On the other hand, it must be admitted that these longitudinal tie-plates form excellent strengthenings to the deck in wake of the principal hatchways, which are of considerable size; but the special strength required at these places can be obtained by other means of a simple character, in cases where no tie-plates are fitted. It may be interesting to add that in the unarmoured iron ships recently built for the navy tie-plates have been entirely dispensed with, and strong stringers alone fitted. One other matter of importance must be mentioned. In arranging stringer plates care should always be taken to make their butts give good shift to the butts of the strakes of skin-plating in wake of the stringers; and the butt fastenings of the stringer-plates and angle-irons should be made sufficiently strong.

Nearly all the preceding remarks apply with equal force to composite ships of the ordinary construction. In them there is an iron sheer-strake to which the stringer-plate is attached; and longitudinal and diagonal tie-plates are also employed. On all except the upper decks, however, it is usual to fit the stringer-plates within the reversed frames; and the reason is obvious, seeing that there is generally only a wood skin in wake of these decks. In some cases, however, strakes of plating are worked in wake of the beam-ends of all the decks, and then the stringer-plates are scored in between the frames and secured to the iron plating. No other points of difference in the deck arrangements of iron and composite ships demand notice.

Stringers and ties such as have been described give sufficient strength to the decks of most merchant ships, but in iron vessels of great size and length additional strength is needed, at least on the upper decks. This want has been met in many cases by adding considerably to the breadth of the stringer, and consequently forming what is termed a "partial iron deck;" and in other cases a "complete iron deck" has been formed by plating over the whole surface of the deck from the line of the hatchways to the ship's sides with continuous strakes, the middle-line spaces between the hatchways being either left unplated or else covered with thinner plating. Complete iron or steel upper decks have been long recommended by some of the greatest authorities on ship-construction; and they have been for many years employed in the iron-clad ships of the navy. Only recently, however, have they found much favour in the merchant service, although a few ships have been so constructed; but with the great increase in the lengths and proportions of ocean steamships, has come the conviction that nothing but advantage results from covering the upper deck with iron or steel plating, and the practice seems likely to become common.

A very brief description of the mode of fitting deck-plating will suffice. The plates are usually flush-jointed at both edges and butts, and consequently rest directly upon the beams, no liners being required. The edges are secured by continuous strips, single-riveted; the butts are covered by double or treble riveted straps. All the joints can be caulked, and the whole plating made watertight if required. In some cases the plan of lap-jointing is resorted to, and the plating arranged just on the same plan as the skin-plating, but this necessitates the use of liners under the alternate strakes which do not fit upon the beams. The butts of the plates are carefully shifted with regard to each other, and also with respect to the butts of the sheer-strake; in fact, the latter precaution is almost as necessary here as it is when only stringer-plates are fitted, if the best possible disposition of the material is aimed at, as it should be, by the ship-builder.

Wood planking, arranged in the same manner as on the decks of ordinary wood ships, is almost always fastened upon the iron deck-plating, and secured by nut-and-screw bolts, which should be kept clear of the beam-flanges, in order that they may be only weakened by the riveting of the plates. Formerly this was not done, but the fastenings of the deck-planks were placed in the beam-flanges just as they would have been if there had been no iron deck. By placing them between the beams, the planking is also secured with greater ease, and it prevents the plating from buckling down under compressive strains. Intimately connected as they are, and each possessed of considerable strength in itself, these two assemblages of plates and planks mutually aid each other in resisting longitudinal strains. The iron or steel deck is of the greater importance when hogging strains have to be resisted, but even against these the wood deck is of considerable service; while the wood deck is most valuable in itself resisting sagging strains, and enabling the plating to develope its strength without buckling. Proposals have been made to give up wood decks when iron or steel decks are fitted, and some ships have been so built. Hitherto, however, it is the general opinion of ship-builders that the use of wood decks is most desirable, mainly on account of the greater comfort gained thereby; and to this must be added the foregoing considerations relating to the joint action of the wood and iron.

This simple arrangement of deck-plating is found to meet every requirement in ordinary iron vessels, and will doubtless lead to the entire disuse of the various detached strengthening pieces—such as "box-stringers," and "vertical stringer-plates"—formerly common in long iron ships. Special requirements, however, have to be met by special arrangements. For instance, in the *Great Eastern*, where extraordinary strength was needed, the upper deck was formed by two iron skins with deep longitudinal girders between; constituting, in fact, a cellular structure in itself capable of resisting great tensile and compressive strains. Again, in the iron-clad ships of the navy it not unfrequently happens that the deck-plating is arranged rather with a view to its powers of resisting penetration by projectiles, than with regard to the strength of the ship considered as a girder. All these exceptional cases must, of course, be considered independently; but in all of them the ship-builder must take care, while giving prominence to the special features, not to overlook the requirement of structural strength, securing both to the utmost extent possible.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVI.—HENRY MAUDSLAY.

BY JAMES GRANT.

HENRY MAUDSLAY, who was the leading workman of Joseph Bramah, and the inventor of the slide rest and the leather collar for the hydraulic press, was born on the 22nd of August, 1771, in an old house opposite the gates of Woolwich Arsenal. Though his father, William Maudslay, was but the storekeeper of the dockyard, he was the lineal representative of an ancient Lancashire family, to whom belonged old Maudslay Hall, near Ormskirk. Through some unfortunate love-affair he enlisted in the Royal Artillery, and served in the West Indies, where he was several times engaged in action, and on the last occasion received a bullet in the throat. After being invalided, he was discharged at Woolwich, but obtained some humble employment in the Arsenal, and ere long had the office of storekeeper assigned him.

When his son Henry was twelve years old, he was employed as a "powder-monkey" in making and filling blank and ball cartridges, and in 1785 he obtained employment in the carpenters' shop of the arsenal, and there first became acquainted with the use of tools and with working in wood and iron. "From the first," we are told, "the latter seemed to have had the greatest charm for him. The blacksmiths' shop was close to the carpenters', and Henry seized every opportunity that offered of plying the hammer, the file, and the chisel, in preference to the saw and plane. Many a cuff did the foreman of carpenters give him for absenting himself from his proper shop and stealing off to the smithy. His propensity was indeed so strong, that at the end of a year it was thought better, as he was a handy and clever boy, to yield to his earnest desire to be placed in the smithy, and he was removed thither accordingly in his fifteenth year."

He rapidly became an expert artisan, and was particularly skilful in forging light iron work, but his favourite employment was to cut "trivets" out of the solid, work which only the most finished hands in the shop could do. These were made out of Spanish iron bolts, which, "though exceeding tough, forged like wax under the hammer." The old workmen, with whom he was a great favourite, were wont to crowd about him when forging these trivets, which he did so quickly and neatly as to excite their admiration. This manufacture of apparatus for supporting toast-plates before the fire was not exactly required at the arsenal, and was strictly forbidden by the superintending officer, so that Maudslay's secret work had to be concealed every time he entered the shop.

He was always fond of any unusual piece of forging, or of having difficulties to overcome, and turned out many beautiful pieces of workmanship in the form of ornaments; but his dexterity as a smith became eventually directed to machinery. His fame as a handy and expert mechanic became known even in London, and his father, the old artilleryman, who was very proud of him, was wont to point to the old military leather stock, which had partly saved his throat from the bullet, and which he carefully preserved, and say—

"But for that bit of leather, there would have been no Henry Maudslay."

He now quitted Woolwich Arsenal and obtained employment in Piccadilly, with Joseph Bramah, who speedily made him foreman in his manufactory, and who was greatly indebted to him for the contrivance of many of those tool-machines which enabled him to carry on the business of lock-making with such profit and advantage. Bramah was inspired by an indefatigable spirit of invention, and the great success of his lock, which he patented in 1784, stimulated him to fresh efforts. His first invention, with the view of creating a motive power, was his hydrostatic machine, founded on the doctrine of the equilibrium of pressure in fluids, as exhibited in the "hydrostatic paradox."

This machine has been used on many occasions in preference to other methods of applying extraordinary power, where such was required, such as when Stephenson hoisted the giant tubes of the Britannia Bridge into their bed, and Brunel launched the *Great Eastern* from her cradles—the weight raised by a single press in the first instance being 1,144 tons! The chief difficulty of Bramah in the construction of the hydraulic press arose from the tremendous pressure exercised by the pump, which forced the water between the solid piston and the sides of the cylinder in such quantities as to render the press, at first, useless for practical purposes, and he found himself completely baffled by this result.

"In this dilemma," says Mr. Smiles, "Bramah's ever-ready workman, Henry Maudslay, came to his rescue. The happy idea occurred to him of employing the pressure of the water itself to give the requisite water-tightness to the collar. It was a flash of common-sense genius—beautiful itself in its simplicity."

Maudslay's invention is thus described:—

"A collar of sound leather, the convex side upwards and concave downwards, was fitted into the recess turned out in the neck of the press-cylinder, at the place formerly used as a stuffing box. Immediately on the high-pressure water being turned on, it forced its way into the leathern concavity and flapped out the bent edges of the collar, and in so doing caused the leather to apply itself to the surface of the rising ram with a degree of closeness and tightness so as to seal up the closer, exactly in proportion to the pressure of the water, in its tendency to escape. On the other hand, the moment the pressure was left off, and the ram desired to return, the collar collapsed and the ram slid gently down, perfectly free and yet perfectly watertight. Thus the former tendency of the water to escape by the side of the piston was, by the most simple and elegant self-adjusting contrivance, made instrumental to the perfectly efficient action of the machine; and thus, from the moment of its invention, the hydraulic press took its place as one of the grandest agents for exercising power in a concentrated and tranquil form."

Maudslay's father died soon after he entered the employment of Bramah, and every Saturday night he walked down to Woolwich, to hand over to his mother the largest share of his week's wages. His fellow-workmen considered him as the hero of the shop, and as he was tall and handsome, on gala days, when the men turned out for a procession, they insisted that he should march at their head, immediately behind the band, and carry their flag. As manager of Bramah's extensive works, Maudslay quite won the heart of his master; but he did more, for he won the heart of the housemaid, a pretty girl named Sarah Tindal, whom he married, and who made him an admirable wife.

Maudslay was eminently successful in the ingenuity with which he devised tools for the most delicate and difficult parts of lock-making; and with his own hands he constructed that identical padlock which so puzzled and tested the powers of Mr. Hobbs in 1851. That lock had then been made for more than half a century, without any of the modern improvements, hence its power was doubly creditable to the skill and dexterity of the artisan who made it. With all the skill and activity displayed by Maudslay in the service of Bramah, his highest wages as manager of his works never exceeded thirty shillings per week. The expenses of an increasing family requiring more, his application for it was bluntly refused. Mortified by this unexpected result, he quitted Bramah and started in business on his own account, in a small workshop and smithy in an alley off Oxford Street. This was in 1792.

There his first customer was an artist, who ordered the ironwork for a large easel, embodying some new and complicated arrangements, and the work was done punctually and to satisfaction. Other orders followed fast. His fame as a skilled workman became as great as that of the master who had lost him, and many who used to do business with Bramah now followed Maudslay to the alley off Oxford Street. He was particularly careful in the style and finish of his work, and it was with this end that he aimed at the contrivance of so many improved machine-tools, which should be self-acting and self-regulating; and hence he invented that important mechanical instrument, with which his name is more usually identified—the slide rest. In this lathe the slide rest and frame were movable along the traversing bar, according to the length of the work, and could be placed in any position and secured by a handle and screw underneath. The rest, however, afterwards underwent many important alterations, but the principle of the whole machine was Maudslay's own invention.

One of the first uses to which he applied it, after he had commenced business in Margaret Street, Cavendish Square, was the execution of the requisite tools and machinery required by the future Sir Mark Isambard Brunel, for the manufacture of ships' blocks. He was then assisted only by a single journey-

man, but he speedily required many more, after the working models were ready for the inspection of Sir Samuel Bentham and the Lords of the Admiralty, in 1801. After being fully approved of by them, Mr. Brunel was authorised to proceed with the execution of the machinery requisite for the manufacture of the ship-blocks of the Royal Navy. The whole of this machinery was executed by Henry Maudslay. It occupied him nearly six years, so that the cutting of blocks by the new process was not begun until the close of 1808.

Many machines were requisite in the manufacture of a single block. Among these may be enumerated the straight-cross-cutting saw, the circular-cross-cutting saw, the reciprocating-ripping saw, and the circular-ripping saw, the boxing and mortising instruments—the latter for cutting stream holes, and furnished with numerous chisels, each making from 100 to 150 strokes per minute; and then came the corner saw, the shaping machine, and the scoring engine, for cutting grooves round the longest diameter of the block. With this new machinery ten men could perform the work which before had required a hundred and more to execute, and not less than 160,000 blocks of all sizes were turned out yearly, at a cost of not less than £541,000, the annual saving to the Government being estimated at £17,663.

This brought fresh accession of fame and business to Maudslay, who removed his works to the Westminster Road, Lambeth, 1810, and established there the famous co-partnery of Maudslay, Field, and Co. There he continued to improve his old tools and to invent new ones, until the original slide-lathes used for making the block machinery became antiquated, and thrown into the shade by the more gigantic machines of the present day. Among other work to which he turned his attention was the construction of plane and saw mills, mint machinery, and steam engines of all kinds; and the *Regent*, the first steamer that plied between London and Margate, was fitted with engines by Maudslay in 1816. He invented the machine for punching boiler-plates, and for many years held the contract for supplying the Navy with ships' tanks. As wealth and years came upon him, he never allowed himself to forget his skill in the use of the hammer, and to the last he took a pleasure in handling it, sometimes in the way of business, but more often through sheer love of his art and the memory of his early days. Among the last works executed by the firm during Maudslay's lifetime, was the famous shield employed by his friend Brunel in the excavation of the Thames Tunnel, the completion of which he did not live to see, as he died on the 14th of February, 1831.

By his own desire he was buried beside his parents in the parish churchyard of Woolwich, a district for which he ever had a great regard, and which he was fond of visiting from time to time. "He liked the clangour of the arsenal smithy," says the historian of industrial art, "and all the busy industry of the place. It was natural therefore that, being proud of his early connection with Woolwich, he should wish to lie there; and Woolwich on its part has equal reason to be proud of Henry Maudslay." A cast-iron tomb, designed by himself, is erected over his remains.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XII.—NATIONAL MUSEUMS (*continued*).

General Details, etc. (*continued*).—Another convenient arrangement, especially when delicate specimens have to be isolated for close examination in the studies, is that of the glazed boxes round and square, with corked bottoms. Usually, these are supplied "nested," consequently of various depths; but sets of subdivisions of a standard size, of a uniform height, afford the neatest arrangement for museum purposes. These may also be glazed on both sides, which like frames glazed on both sides are useful for the display of rare objects that require examination, both on their upper and lower surfaces. Flat bottles (Fig. 16), such as are employed by Mr. Twining, are useful for the display of seeds, powders, etc. Next in convenience are the ebonised bowls (Fig. 17), closed by glass discs that drop into a rebate in the rim. These are useful for the display of sands, grains of metals, small nuggets, etc. Where small quantities of material have to be made the most of, the bottoms of such bowls may be filled up with lenticular shaped blocks, A (Fig. 17), which bring the sand, etc., up to the covering glass. Allied to these are the specimen glasses (Fig. 18), covered with flat plates or watch glasses, that are specially suited for separate crystals, chemical products, etc. Cast rods of metals, etc., can be well displayed in tubes, the stoppers of which form stands as in Fig. 19. The hermetically sealed tubes in which the alkaline metals potassium, sodium, etc., are supplied are best mounted on an ebonised wooden foot that conceals the unsymmetrical portion, as shown in Fig. 20. Gems, crystals, etc., may be supported in shallow cups or on the points of ebony or ivory conical pegs, as in Fig. 21, or be held in the grasp of double or triple limbed tweezers (Fig. 22), with pointed ends that allow of such objects being placed at any angle that best catches the light to bring out its play or colour, etc. Preparation jars are round or oval, as shown in Fig. 23, are made of various sizes, but when filled with preservative fluids have the disadvantage of producing optical distortion, so that unless the object is very large, it is better to display dissections in flat cemented cells, built up of glass slips, slabs, and covers, or, better still, made from sections of square, oblong, oval, or round bottles, cemented to base and covering glasses, as shown in Fig. 24. Where objects are unsuitable for display in a public gallery, such as jelly fishes, microscopic objects, etc., they may be represented by transparent photographs which may be coloured with great delicacy, and a more perfect rendering of hyaline aspect than can be given in water-colour drawings. Such paintings on glass must be supported on tin frames of the form shown in Fig. 25, the upper half being japanned dead black, the lower half white; as this is for the purpose of reflecting light through the transparent illustrations, the tin allows of the glass being adjusted to the most suitable angle. In the elementary collections such photographs may be utilised as magic-lantern slides for the illustration of lectures to large audiences when colossal diagrams of objects described are essential to a clear comprehension of details of structure. This is the only way of showing lettered classifications, so as to be discernible in a large lecture theatre.* A very useful arrangement has of late years been introduced into museum fittings by Mr. Twining, shown in Fig. 26, that consists of an iron standard on a tripod foot, to which are hinged a series of iron frames that may be fitted with specimen bottles, trays, herbarium cards, diagrams or photographs, which may be turned over like the leaves of a book. These hold a great number of specimens, while they occupy little space, and would be of especial service in the botanical gallery. Strong iron cradles, frames, etc., made of iron, are required for the support of special objects, such as the tusks of the mastodon, carapace of the glyptodon, restored skeleton of the great extinct sloth, etc., at the British Museum.

Fig. 27 shows a convenient form of label. In tropical countries it is necessary to protect specimens from moth, white ants, and other destructive pests, by preserving them in tight-fitting metal cases, which, if required for public exhibition, may be glazed on the top side; attention being given to the way in which the glass is cemented into its fitting.

Details of Rotunda of Elementary Natural History.—As a small collection is found to be more readily understood and made available for the uneducated classes, and those who have not studied very profoundly—numerous specimens of species rather confounding than assisting such persons—the arrangement of this supplemental building is specially disposed for the display of an epitome of natural history or index collection, introductory to the systematic series, and for the same being open for inspection in the evening as well as during the day or even, as recommended by Dr. J. E. Gray before the Parliamentary Committee on the British Museum, on Sundays also. The elementary collections in this department should illustrate by external form, skeleton, skulls, dental formulæ, internal and microscopic structure, developmental phases and embryology, the characteristics of the classes and orders of the animal and vegetable kingdoms, zoological, botanical, and mineralogical terminology; and the classification being illustrated by the collections of British natural history, interspersed with the most important exotic species which have not representatives in the British series. All such specimens should be arranged so that they could

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* See Vol. II., page 244.

be utilised for popular lectures on the general principles of natural history. As the typical collection would embrace a similar series to that which should form the basis of every local museum, I shall defer a detailed description thereof till I have to treat of museums of the latter class. The ethnological and geographical distribution collection should form one series, and be arranged in large groups, artistically arranged with scenic backgrounds in cases at least 10 feet deep, so as to convey a just idea of the natural association of plants and animals with the human race in geographical regions, and of the representative species of different countries, and distribution of life in oceanic depths after the manner foreshadowed by the lamented Edward Forbes at the Crystal Palace, though such illustrations can only be regarded as sketches of what ought to be worked out in detail at the new Museum. Each case might be conventionally divided *in idea*, as indicated in Fig. 28, so that the species of every associated geographical group should find its place according as its maximum of development was to the north, east, south, or west of the geographical region illustrated. In the same room, the position of our earth in the solar system should be shown by a simple orrery, which should also indicate the relative diameters of the planets, their mean distances from the sun, and such other details as the huge dome of the Rotunda would admit of.

The floor of the ethnological and geographical gallery might be occupied with cases containing small models, such as those shown at the Exhibition of 1862 by Montanari and Heiser to illustrate varieties of the principal types of the human race, and the costumes of the inhabitants of the various regions of the globe. The life-like illustrations of bathymetrical distributions might be displayed in tall but shallow cases, artistically arranged to give an idea of sub-aqueous life, vegetable and animal.

Such a gallery would be one of the most popular as well as the most instructive in the elementary series, as being most readily comprehensible by the uneducated.

Details of Lecture Theatre.—This would be seventy feet in diameter, lighted by day from a glass ceiling opening into the dome of the Rotunda, after the manner of the theatre at the Museum of Practical Geology, and by night by a "sun-burner," which would also be an active element of ventilation. The thick glass ceiling could be guarded in the upper floor by a circular range of cases, serving the place of a balustrade without material loss of space. The theatre should be arranged to accommodate at least 1,000 persons, and provision should be made for the illustration of the lectures by monster diagrams, tables of classifications produced by aid of the demonstrating lantern, which is the only method of making structural details and lettered diagrams distinctly visible to the whole of a large audience, a method that year by year is gaining favour, and rendering the old magic lantern in its modernised form a powerful instrument of education, by the way in which it conveys information through the eye; and as long as we can teach well and quickly, "sight knowledge" is a thing not to be sneered at by instructors of the old school.

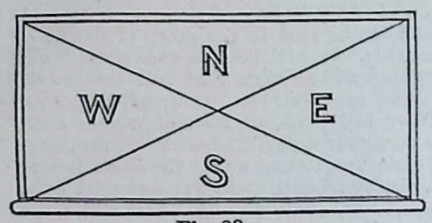


Fig. 28.

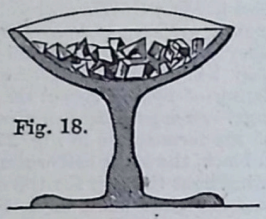
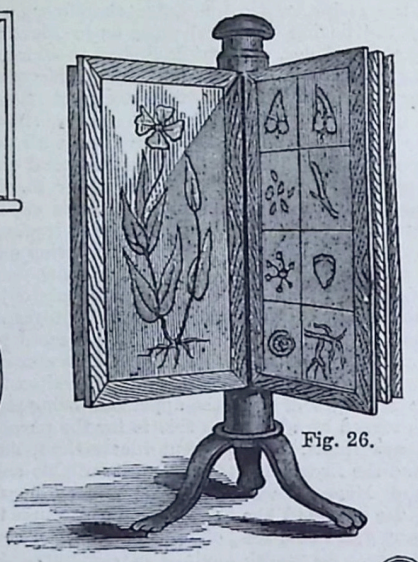


Fig. 18.

Fig. 22.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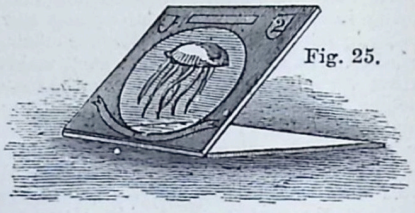
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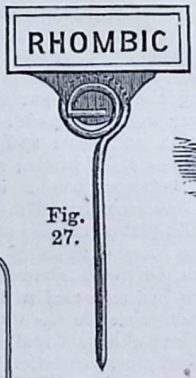

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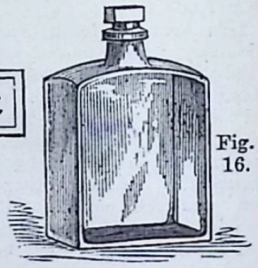
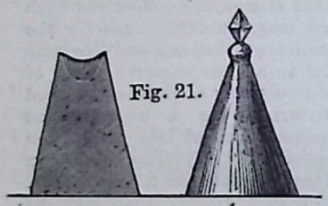


Fig. 16.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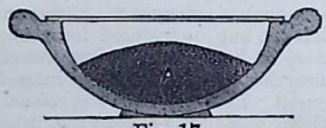
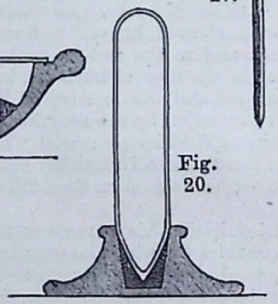


Fig. 17.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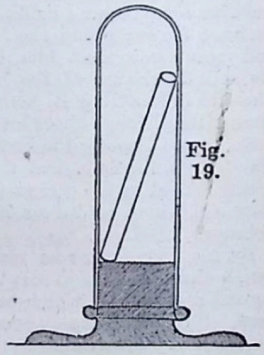
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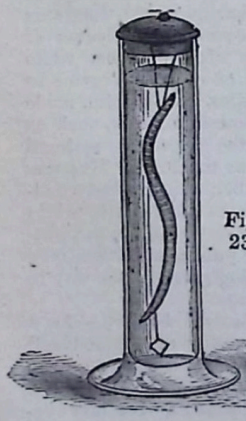
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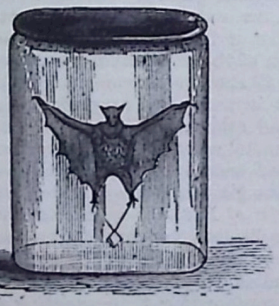


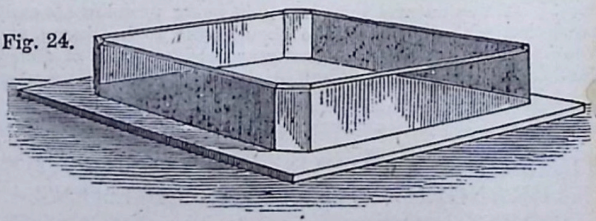


Fig. 24.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By Professor T. C. Archer.

I.—THE NATURE AND PROPERTIES OF WOOL.

The term *wool* is applied to that particular kind of hair which reveals, by aid of the microscope, a peculiar transversely imbricated structure, upon which chiefly depends its value as a textile material. Besides this peculiarity, wool possesses another which increases its usefulness: it is longitudinally waved.

These properties cannot be well understood without the aid of drawings, and these must be somewhat exaggerated in their details, as well as in their size. They exist in the greatest perfection in the fleeces of the cot-fed Merino sheep of Bohemia and Hungary, a tuft or lock of which is represented of rather more than its full length in Fig. 1. If from this we draw out a single hair, we shall find it is extremely thin, finer even than the thread of the gossamer spider, and that it is regularly waved in the manner shown in Fig. 2.

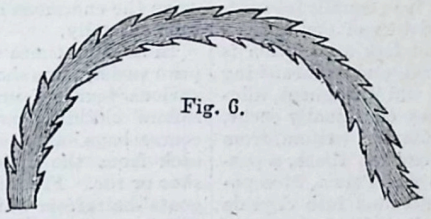


Fig. 6.

As we have before stated, this represents the highest perfection of one class of wools, which from their shortness are called *short-stapled;* but there are some other kinds in which this type is very widely departed from, in which the wool is very much longer, and the curves are altogether different, as in Fig. 3, which may be taken to represent the class called *long-stapled.* Between the extremes shown in these figures there is every possible gradation, and these qualities are more or less visible to the eye and touch of the experienced *wool-stapler*, and also to that of the manufacturer; but the other and more remarkable quality of wool, its imbricated structure, cannot be seen by the unassisted eye. As with the waves or curves, so also with the imbrications or scales, differences exist, which are distinctive of the short and long-stapled varieties. If we magnify a single hair of the finest *short-stapled* kind to about 150 diameters, we shall find that it is marked transversely by very distinct and apparently irregular striations, which will be seen on further examination to be the edges of scales overlapping each other, after the manner of tiles on a roof. Fig. 4 gives an exaggerated view of a fibre so magnified, and Fig. 5 an imaginary longitudinal section of two fibres laid in opposite directions. That the scales are free except at their bases, can be easily seen by examining one when bent, as in Fig. 6, when the scales will be lifted up at their points. These may appear very trifling matters, but they are of so much importance that without them wool could not be applied to the purposes of weaving by any of the processes now known. Besides the special form and arrangement of these scales, their number is also a matter of great importance, and this varies quite as much, or even more so, than the length of the curves; thus, in the very finest of the *short-stapled* kinds, as many as 4,000 have been counted in the length of an inch, whilst in the long staples they rarely exceed 2,000, and are often not more than 1,200 in number.

Fig. 1.

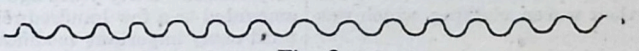


Fig. 2.

Fig. 3.

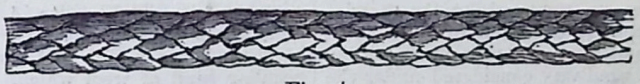


Fig. 4.

Fig. 5.

Now, if we take a few hairs not possessed of these qualities, human hair for instance, and twist them together, we find that they will not retain the twist, but straighten themselves, as soon as the ends are liberated; but a similar number of wool fibres so twisted retain that condition and form a thread. This arises from the fact that the scales hook into each other whenever they are forced into contact, and thus the fibres become inextricably interlocked: this will be the more complete in those varieties in which the scales are most numerous; and the curves will of course aid much, as when twisted they cause the individual fibres to form spirals. Of course, this interlocking would not be so complete if all the fibres were laid in the same direction, but this is practically impossible with wool, as the simplest mode of preparing it is sure to prevent such a result. Therefore, if two fibres come in contact in opposite directions, as in Fig. 5, we see at once what must be the result if they are twisted—the scales of one will slip under or over those of the other, and they will be thus held together. If the twisting has only been done slightly, the scales will only be held by their points; if much twisted, the scales will be inserted under one another as far as they can go. In the former case the length of the thread produced will not be much less than that of the fibres employed; in the latter it will be much shorter.

There is one still more minute quality in these scales, which is not generally noticed, but it is of very great importance; it is that the under side is not perfectly smooth, and this offers some resistance to the interlocking of the scales. This is proved by the fact that when a lubricating fluid like soap and water is used, the interlocking is rendered more complete and permanent.

This peculiar property of wool is called *felting*, and it will be seen that this causes the shrinkage of woollen clothing when washed; the rubbing, the soap and water, and the wringing, are all operations which are sure to make the fibres of wool work together to the fullest extent they are capable.

So remarkable is this property of felting, that with many kinds of wool it is only necessary to mingle the fibres, wet them, and beat them gently, to get them to combine and form a fabric, which is used in various ways for clothing, under the name of *felt*, which will be hereafter described.

So far, sheep's-wool has been the type before us, because no animal produces wool so perfect in all its essential qualities; indeed, so perfect is it, that without a full knowledge of the physiology of this most useful of animals, it is a matter of no little wonder that the immense mass of wool which constitutes the fleece of a single sheep, does not, from the movements of the animal and other causes, felt into a compact mass upon its back. We find, however, a provision in the economy of the sheep which secures it from such an evil.

A large portion of the skin of the sheep exudes a secretion known by the name of *yelk*, which is a kind of natural liquid soap, as it contains both oil and the alkali potash. This lubricates the fibres, which on the skin of the animal are all held in one position; hence, they are kept freely moving upon one another during the motions of the animal, and do not, consequently, *felt*. So abundant is this secretion, and so large the amount of alkali present in it, that it has been suggested that the waters from sheep-washings should be used as a source of potash; and at the Cape of Good Hope and in France, this valuable and not very abundant alkali has actually been recovered with profit from the water in which sheep have been washed.

Most animals which are clothed with hair have two kinds: one smooth and unprovided with the scales which distinguish wool; the other, usually the undergrowth, which either has such scales or some modifications of them. The latter is called either *wool* or *fur;* the term *wool* is, however, very limited in its application, whilst the number of fur-bearing animals is very considerable. For technical purposes, it is convenient to dis-

tinguish them thus:—*Wools*, those animal fibres which can be both spun into yarn and also felted. *Furs*, those which can only be felted.

The true wool-bearing animals are the sheep, the Cashmere goat, the alpaca, the llama, the guanaco, and the camel. As no animal in an absolutely wild state produces wool in such abundance as these, there is some reason to suppose that it is largely due to the changes produced in the animals by domestication. The guanaco might almost be excepted, for it is so wild that it has to be hunted; nevertheless, it yields an inferior kind of wool used only by the Indians and Mestizos of Peru.

The chief of all wool-producing animals, the sheep, is so remarkably connected with the history of man, that no fossil remains of the animal have ever yet been discovered which are not clearly referable to times coeval with the human race; at least, this is the case with respect to Europe, and leads to the inference that it has been introduced from some other part of the world by man in his migrations. And it is equally interesting to find that it is associated with the history of our race as far back as any historical records exist, and this association is due to the use of the animal both for food, and in furnishing materials for clothing. Throughout the Old Testament, allusions to the rearing of sheep and their uses continually occur, and they are equally numerous in the old classical writers, from whose writings we gather that, from the earliest times, a pastoral life was common to all the inhabitants of Persia, Mesopotamia, Syria, Palestine, and Arabia, and extended into Scythia and Tartary. Indeed, there is no want of evidence to prove that the culture of the sheep for its wool, as well as its flesh and milk, was common throughout the greater part of Asia Minor and Scythia before Greece planted its colonies in those districts; and in very ancient Græco-Scythian antiquities discovered on the site of the colonies of Panticapæum, representations are found showing the highly pastoral character of the people, and the perfection of their woven clothing, which was doubtless of wool.

The Greeks and Romans, from the commencement of their respective histories, were familiar with the wool of the sheep, and reared varieties of different qualities. The wools of Miletus and of Phrygia were famous for ages, and form themes for their historians and poets; and so famous were the fleeces of the Attic sheep, that the shepherds covered them with skins in bad weather to preserve and improve them, whilst the district of Arcadia has obtained an immortal celebrity for its pastoral life. Moreover, from the times of the most ancient Greeks to the later Romans, the trade in wool was considered under the especial protection of Mercury.

Amongst the Romans wool was held in high esteem, and various breeds had great celebrity—a celebrity which exercised the pens of their most famous writers. Virgil and Pliny, Varro, Tertullian, and Columella, have all left abundant evidence in their writings that the subject was considered worthy of such celebrated writers, and that the shepherd's life was regarded with great favour in their days; for we cannot class their writings with those of the poets of our own country, who make the pastoral life the basis of many of their amatory songs and poems.

But however abundant the evidence of the use of wool, and consequently the rearing of sheep, by the nations of classical and Biblical antiquity, we are entirely without information respecting the introduction of the sheep to Britain. As before stated, the negative evidence of the absence of true fossil remains forbids the assumption that the animal was indigenous; and although assertions have been made that sheep were introduced by the Phœnicians, that wonderful people who are made to account for so many difficulties, yet there is no actual proof that our forefathers had seen the sheep when Cæsar landed on our shores, or for a hundred years afterwards. In all probability, we are indebted to our conquerors for this useful animal, and we certainly are for the first establishment of a woollen manufactory, which was founded at Winchester in the time of Agricola. From that time we know from various sources that the trade flourished, and that it also became a female accomplishment of the highest character (whence the term *spinsters*) to work the wool up into fine yarns, and even to weave it into garments; whilst those men who were engaged in rearing sheep, although sometimes called shepherds, were held to be persons of distinction, and their daughters could mate with kings, as in the case of King Edward I., whose first wife, Egwina, was the daughter of a shepherd; and the princesses his daughters were skilled in spinning wool. In subsequent papers will be given the various methods employed in those primitive times, as well as at the present, for preparing the wool for the various purposes to which it is applied.

Next in importance to the wool of the sheep is that of a species of goat (*Capra hircus*), a native of Cashmere and the elevated table-lands of Thibet, where it thrives at an elevation of from 12,000 to 16,000 feet. It also abounds in the mountainous districts of Asia Minor, and one of its varieties is reared in vast numbers in the neighbourhood of Angora, whence it is called the Angora goat, the fine, long, silky hair or wool of which forms a very important article of commerce, so much so that the imports to Great Britain alone represent an annual value of over half a million sterling. The greatest quantity comes to us from the various ports of Turkey, from which alone we receive the enormous quantity of between nine and ten thousand tons annually.

In ancient times we know that the common goat, the European variety, was shorn of its hair, which was manufactured into various textile fabrics of the coarsest description, such as sailors' clothing, coverings for tents, and especially for such coarse bags as we now call sacks; in fact, we derive the word sack from the Hebrew name of goat-hair cloth, which was *shac* or *sac*. From the fact that the Romans obtained the best goats'-hair from Cilicia, cloths made from it were also called Cilicias, and we still use the term slightly altered for a class of fabrics made from sheep's-wool. The fine wool yielded by the goat of Cashmere and Thibet, and the beautiful material which, combining the qualities of wool and hair, is yielded by the Angora goat, were both unknown to the Greeks and Romans, and our acquaintance with them is comparatively very recent. Fifty years ago the imports of this material only amounted to a few hundredweights per annum, and it was not until many important modifications in the machinery for spinning it had been perfected, that it attained to the great importance which it now has in our manufactures, under the name of mohair. The wonderful improvements which have been made in that time in carding machinery, have led to a vast extension of the trade in mohair, and to the use almost equally extensive of another beautiful wool, that of the alpaca (*Auchenia pacos*) and its allied species (*A. llama* and *A. huanaco*). These animals are natives of the Peruvian Andes, where, besides two of them being useful as beasts of burthen, they all yield a peculiar kind of wool which, besides being very long, is exquisitely soft, and beautiful in lustre. In the time of the Incas beautiful cloths were made from the wool of these animals, specimens of which are still occasionally found in their tombs; but it was not until about 1840 that its usefulness was fairly recognised in this country. Now the annual importation is over three millions of pounds, and the value nearly half a million sterling, giving employment to many thousands of people in the production of beautiful fabrics, which will be more fully described in a subsequent paper. The only other animal which yields hair which has the properties of wool, and is used as such, is the camel. This creature is ordinarily covered with a thick coating of soft brown wool, amongst which are sparingly mixed long smooth hairs. When these are separated, they are of great use in the making of small paint-brushes for artists, and the wool can be spun and woven into cloths of beautiful quality, as to softness and durability. Eastern nations use it extensively, but it has not been employed in Europe, except in Russia, where it is in great favour for military clothing, and is as much in fashion as the scarlet woollen cloths are in our military service.

Besides the true wools, and those varieties of hair which also have the properties of wools, all the true furs possess the property of *felting* in a remarkable degree; they are very numerous, but only a few of them are sufficiently abundant and cheap to be used in making textile fabrics by the process of felting. Chief amongst those which are so employed are the hare and rabbit, called in commerce coney-wool; the beaver, though very little, compared with its former extensive use in the manufacture of hats; the musquash (*Fiber Zibethecus*); the nutria or coypu (*Myopotamus coypus*). These materials are very extensively employed in the manufacture of felt hats, usually, however, in a state of mixture with sheep's-wool. In

the next article on woollen manufacture will be described the fabrics made from these materials in the earliest times, as an introduction to subsequent papers on the modern manufactures.

CAPITAL AND LABOUR.—IV.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

CAPITAL AND WAGES.

There is a very general opinion that the amount of wages procurable by those who labour depends on the amount of capital which is capable of being employed in the payment of wages, and some writers have thereupon discovered what they have called a labour-fund, meaning by this the quantity of property in the hands of those who employ labour, concluding that this property is the sole cause why labour is employed at all. It is further imagined that as this fund increases and diminishes, so the condition of labourers is bettered or made worse; and a quantity of ingenious reasonings have been propounded, and a number of ingenious precautions suggested, which have for their object the sustentation of this labour fund, and the prevention of those direful consequences which might be expected to ensue, were the fund curtailed, or rendered less manageable for the purpose to which it is to be devoted. If, however, we are able to show that this labour-fund is a mere creation of fancy, which has no reality, all these alarms will be shown to be as baseless as their object is.

There is always a foundation of truth in any wide-spread delusion. The truth may be very small, and it may be used for the development of such vast errors, that it may become mischievous by its incidental or inveterate connection with these errors, and thereby it may do much more harm than good. In the matter immediately before us the truth as to the relations of employer and workmen is that the manifest convenience of such relations is so considerable that they are frequently supposed to be all important. Again, any interruption of these relations brings about so serious an inconvenience that people may well be pardoned for exaggerating the significance of such facts as really exist. For example, the wide-spread distrust which prevailed for some months after May, 1866, when an eminent house of business in London was proved to be wholly bankrupt, was so serious, that infinite injury was done to every branch of industry by the recklessness and deception of the persons referred to. People did not know on whom they might rely, and in consequence business was paralysed; for credit is so very delicate an instrument, that though it is capable of most astonishing feats of power, it may be deprived of all its energies and collapse.

Labour is not set in motion by the property of the employer, but by the demands of the public. Houses are not built, cloth is not woven, books are not printed, because builders, spinners, and printers have property, but because the public is prepared to purchase each of these articles. If no such desire existed on the part of the public, the property of employers would cease to be productive, and the action of employers would cease. This position is so plain that it needs only to be stated in order to be immediately acknowledged and admitted. No industry can exist or continue unless the public requires the product on which the industry is exercised. Nay more, if for some reason the product in question may be obtained more cheaply and conveniently from some other source besides that which has hitherto supplied it, and the public is allowed to obtain it from that source, the industry which is now made less effective will be discouraged, and, unless it can accommodate itself to the altered circumstances, will finally come to an end. However abundant the property of the employers may be, nothing but public demand can keep an industry alive.

Now the capitalist employer, when such a demand exists, performs two important services. He interprets or measures the extent of the demand for the object in which he trades (not always exactly, for he frequently produces too much, and may produce too little of the article), and he keeps the price of the article pretty steadily up to the cost of producing it. Much time would be lost if the workman were seeking the customer or consumer of the article which he produces, and much labour would fail of occupation were there no person who found out, as his proper business, the means for bringing producer and consumer together. Again, the workman has constantly very little beyond his labour to sell. If he employed himself on producing articles which he took to market himself, the price of that which he makes would be liable to sudden and frequent changes, as his necessity forced him to sell, and the wants of the customer were unsatisfied. Now there is nothing which a producer desires more than as uniform a price as possible for that which he makes. It is this result which the employer brings about. He is able to hold goods back from the market, because by the possession of his property he can wait till a fair price can be obtained for the article in which he deals. His position, then, is essential towards the true interpretation of public demand and its regular supply. But he does not set the labour in motion. This result is obtained because the labour can do something which is useful, and so will be purchased or employed.

The employer, then, buys labour, which he sells again, either by hiring out the labourer to the customer, or by disposing of those articles in which labour has been condensed. Sometimes the service which he does to the labourer in relation to the two points just adverted to is very slight. For instance, the master baker has probably sold, and has been paid for the service which his journeymen perform long before he has paid them for the work which they have done. But in the great majority of cases the work of the labourer is paid for some time before the price of the work has been recovered from the public. Occasionally the work service or to be performed is of such a character that a very large sum has to be laid out, and laid out permanently, before any payment can be obtained. The cost of constructing a railway is very great, and must be incurred before any charge can be levied for the conveyance of passengers and goods. Were it not for the capital of the employer—*i.e.*, of the railway shareholders, acting through the managers or directors—no service whatever could have been done. The shareholders have rendered it possible that workmen should be employed in rendering the service. But when the road is laid down, and the carriages and engines are supplied, the trade of the shareholders is characterised by even more rapid returns than that of the baker referred to above. The railway receives the payments for passengers and goods long before it pays those persons whom it hires to do the work for the public. In other words, after the first outlay, the demand of the public finds the means for paying the wages of the railway servants to a far more notable extent than is the case in any other trade.

The inaccurate and unphilosophical language often used about the relation of labourer and employer, under which the former is made to appear as though he owed his employment and subsistence to the latter, has led to very serious inconveniences, for it has constantly estranged workmen from their employers, and has given an impression that the relations between them are those of patron and dependent. Rightly considered, there is no more dependency between the two than there is between the miller and the farmer. In order that a farmer may sell his corn it is no doubt necessary that the miller should be at hand to buy and prepare it for the public. But similarly, in order that the miller should set his mill going, it is necessary that there be a farmer who shall supply him with corn to grind; and much more important still, neither the farmer would find a market, nor the miller get his living, unless the public were prepared to use the corn of the one, and employ the services of the other.

The employer, then, is a dealer, or go-between. His real value in the economy of society is not disparaged by pointing out what his true position is, and by stripping it of those pretended powers which it never possessed, and never could assume, if its real meaning were investigated. Like every other person who gets employed, he has a use, and a very important one. He would not, indeed, occupy the position which he does, if there were not a notable use in the office which he fills. But like the labourer whom he employs, he is paid for his labour, and because his labour is acknowledged to be useful. Similarly, just as any kind of manual labour may be superseded if some machinery may be found to supply its place, so it is possible that the office of the employer may be superseded, if a better and cheaper substitute can be found for it. I say *possible*, for as far as human understanding can determine, the relative conditions of employer and employed will exist, like rich and poor, as long as the world lasts.

TECHNICAL DRAWING.—LXXVIII.

DRAWING FOR CABINET-MAKERS (*continued*).

The first example given in this lesson (Fig. 610) represents a small mahogany wardrobe, drawn to the scale of $\frac{3}{4}$ inch to the foot. It consists of a drawer and two compartments, the one of which may be fitted with trays and the other arranged for hanging.

In commencing to draw this object, erect the central perpendicular, and draw the ground-line. Set off on each side of the perpendicular, A, half the width of the plinth, the entire width of which is 3 feet 6 inches; and at these points, B and C, erect perpendiculars 3 inches high. Join these by the horizontal line D E, the upper line of the plinth.

Now the width of the body of the wardrobe is 3 feet $4\frac{1}{2}$ inches, the plinth projecting $\frac{3}{4}$ inch in the front and on the two sides. Having set off half this measurement on each side of the centre line, draw the perpendiculars F and G: these may be indefinitely high, as they form the sides of the entire wardrobe.

Draw the horizontal line H I, for the lower line of the small cornice which separates the drawer from the closets above. This projects 1 inch on the front and sides, and is $1\frac{1}{4}$ inch thick, including the fillet. The height of the closets is 4 feet 10 inches to J K, and the entire cornice is 6 inches high.

Draw the horizontal line J K, and the others required for the cornice, which may then be completed. It will be seen that the moulding is that shown in Fig. 120 (Vol. I., page 200), viz., the *cyma reversa*.

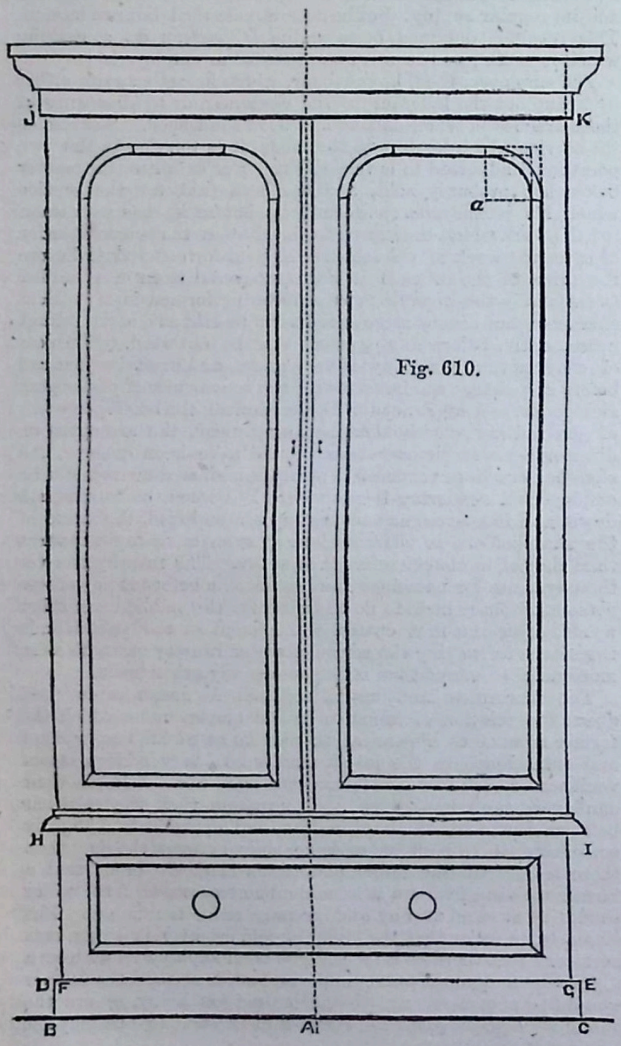


Fig. 610.

The bead covering the meeting of the doors is now to be drawn, half its width being set off on each side of the centre line. Within the two rectangles thus formed draw the panels. It will be seen that the curve uniting the top with the sides of the panels is a quadrant, the centre of which is at *a*.

Fig. 611.—The next example here given represents a small bookcase with closets at bottom, drawn to the scale of $\frac{3}{4}$ inch to the foot.

Above the closets is a drawer for music, manuscripts, etc. The top of the lower case projects on the front and sides, and is moulded with a quarter-round and fillet. The moulding of the cornice is the *cyma recta* (Fig. 116, Vol. I., page 200).

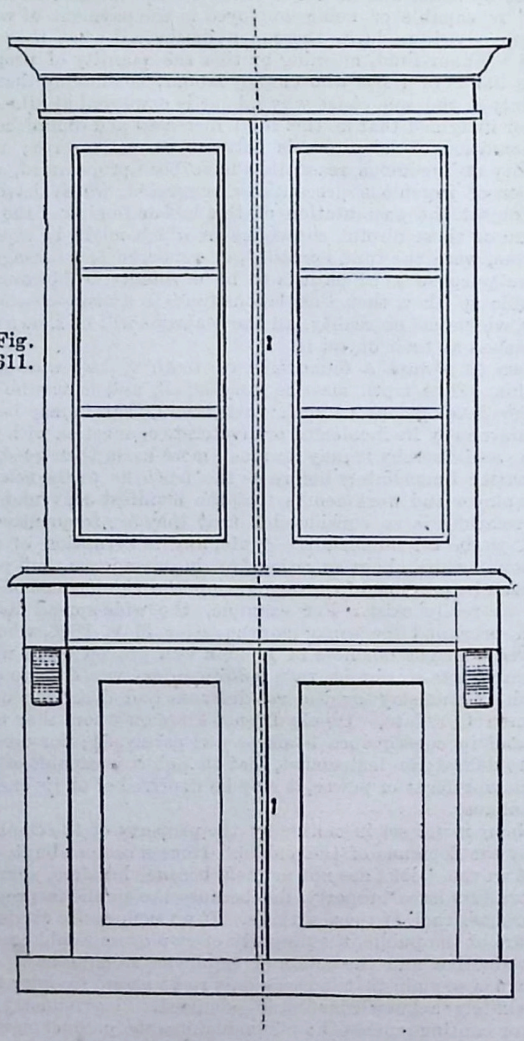


Fig. 611.

The measurements of this object may be obtained from the example, the method of drawing which is so precisely similar to the last that no further directions are deemed necessary.

PERSPECTIVE FOR CABINET-MAKERS.

The subject of Perspective is one of much importance to the cabinet-maker. We do not mean that this particular branch is used in the workshop; there, Practical Geometry and Projection form the fundamental methods by which the working drawings are made, whilst freehand drawing, of course, occupies in the ornamental portions of the trade a very high position.

By means of Perspective, however, drawings of the various articles of furniture are made in order to enable the customer to judge of their appearance, and it will be easily understood how, in a business point of view, the power of making such drawings may benefit the artisan, and how valuable to his employer a man may become, who, when calling on a customer, is

able from his oral description, to sketch out the article on the spot, in such a manner that the artist employed in the establishment can make a finished drawing, from which the working drawings are subsequently to be made. And, further, by means of a practical knowledge of model drawing, which is the freehand application of perspective, a young workman who carries with him a small sketch-book and pencil may lay up a store of sketches, which will be invaluable to him on a future occasion.

As Perspective is treated of in a separate series of lessons, to which (Vol. I., page 292 of THE TECHNICAL EDUCATOR) for details of the principles the student is referred, we here proceed to show the application of these principles to the special branch of trade which forms the subject of the present course.

A mere glance at the earlier lessons on "Practical Perspective" will therefore suffice to remind the student who has gone through them, of the general principles; and having done this, he can at once proceed to the advanced studies. He is, however, urged not to be content with this, but to take up the subject as a separate study, of which he will find the advantage as he proceeds with the other branches of his art. Indeed, it may be said that the workman, however expert and ingenious he may be in the use of his tools or implements of his craft on the one hand, and in forming contrivances for facilitating his work and imparting to it stability of form or beauty of structure on the other, he can never consider himself entitled to be classed among those who are at the head of their vocation until he has acquired a knowledge of perspective, which is not only the foundation of success in the higher walks of art, but the basis also of well-doing in all the vocations, be they what they may, to which the art of drawing is ancillary.

Fig. 612.—The subject of the present lesson is a rack of book-shelves, drawn to the scale of $\frac{3}{4}$ of an inch to the foot.

The external width of this case is 3 feet, and the total height is 7 feet 1 inch, made up as follows:—

	Inches.
The top, bottom, and six shelves, made of wood 1 inch thick	8
The 1st space from the bottom	14
,, 2nd ,, ,,	13
,, 3rd ,, ,,	12
,, 4th ,, ,,	11
,, 5th ,, ,,	10
,, 6th ,, ,,	9
,, 7th ,, ,,	8
	85 in. = 7 ft. 1 in.

Having, therefore, drawn the rectangle bounding the front of the entire case—viz., A B C D (3′×7′ 1″)—mark the point of sight and the point of distance.

Now the height of the spectator is supposed to be 5 feet, and thus the horizontal line (*h l*) is to be drawn at that distance from the picture line, and as the object is to be represented as standing at 6 feet on the left of the spectator, the point of sight is to be set off on the horizontal line at that distance on the right of the perpendicular, A D. The distance of the spectator—viz., 11 feet—is then to be set off from the point of sight on the horizontal line on the other side of the object.

In order to economise space these points are not placed within this figure.

The depth of the case externally is 1 foot. To show this, draw lines from A and D to the point of sight, set off 1 foot on the picture line from A—viz., A E—and draw a line from E to the point of distance, cutting the line drawn from A to the point of sight in F. At F erect the perpendicular F F′, which will be the back line of the case, thus rendered as a mere block.

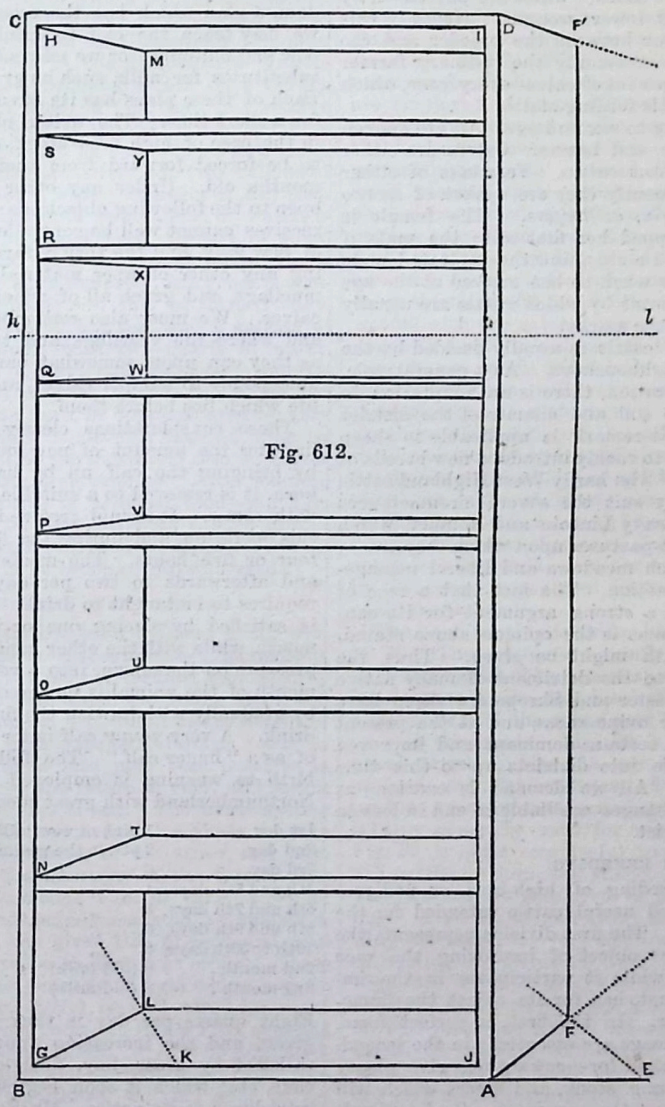


Fig. 612.

The thickness of the wood of which the entire case and shelves is made is 1 inch, and this is now to be represented by the inner rectangle G H I J.

The interior of the case next claims attention, and to project this draw, in the first place, lines to the point of sight from G and H.

Now it will be remembered that to obtain the depth of the case *externally* 1 foot was set off from A—viz., A E—and a line drawn from E to the point of distance, intersecting A, gave the point F, the place for the distant perpendicular F F′.

The same system is now to be pursued; but the *interior* depth is 1 inch less than in the previous case, the back of the case being made of wood 1 inch thick; therefore,

From G set off G K (11 inches by scale), and from K draw a line to the point of distance, which, cutting the line drawn from G to the point of sight, will give the point L. From L draw a perpendicular, cutting H in M; from L and M draw horizontal lines, which will complete the representation of the carcase of the case, the shelves only remaining to be drawn.

On J I set off the respective heights of the spaces and thickness of the shelves, and draw horizontals, giving the front edges of the shelves.

It will now be evident, that as some four of the shelves are below the horizontal line, their upper surfaces will be seen, whilst of the two which are above the level of the eye of the spectator, the under side will be visible. Therefore from N, O, P, Q, R, and S, draw lines to the point of sight. From the points where these cut the perpendicular, L M, viz., T, U, V, W, X, Y, draw horizontals, representing the distant edges of the shelves, and the drawing will thus be completed.

The learner need scarcely be told that as the figure under consideration affords a correct representation of the rack of bookshelves only according to the point of sight and point of distance that has been used in this case, it will be a useful exercise for him to vary these points, and so form a series of representations of the same object from different points of view.

FARMING AND FARMING ECONOMY.—XVI.

By Professor Wrightson, Royal Agricultural College, Cirencester.

MANAGEMENT OF CATTLE.

DIVISIONS OF THE SUBJECT—TERMS EMPLOYED—ADAPTATION OF BREEDS TO THEIR LOCALITIES—MANAGEMENT OF THE CALF—OF YEARLINGS—OF TWO-YEAR-OLDS.

Cattle management may be divided into three branches—breeding, rearing, and fattening. Occasionally they are followed separately, but more usually are practised upon one and the same farm. The occupiers of high-lying moorland or of mountainous tracts raise "store stock," which are purchased by the graziers of the richer and lower grounds. Hence in this case there is a division of labour between the breeder and the beef manufacturer; but more commonly the ordinary farmer keeps a few cows and brings up a lot of calves every year, which eventually find their way into his feeding stalls.

Cattle are classified according to sex and age. All are spoken of as horned stock, neat cattle, and beasts. Calves are either *bull calves* or *heifer, quey*, or *cow calves*. Yearlings of either sex are called *stirks*. Subsequently they are spoken of as *two* and *three year old bulls, steers*, or *heifers*. The female is called a cow after she has dropped her first calf; the male, if castrated late in life, is termed a *stag*, and the castrated male or *steer* becomes a *bullock* or *ox* when he has arrived at the age of four years. Such are the terms by which cattle are usually designated on the farm and in the market.

The selection of a breed of cattle is usually decided by the previous experience of the neighbourhood. As a general rule, worthy of the gravest consideration, there is an adaptation in the case of every breed to the soil and climate of the district over which it has spread. This remark is applicable to sheep as well as cattle, and attempts to rashly introduce new breeds of either into a district often fail. The hardy West Highland cattle and black-faced sheep exactly suit the severe circumstances under which they exist; the heavy Lincoln and Romney Marsh sheep require the flat luxuriant pastures upon which they graze; and the shorthorn requires rich meadows and liberal management to maintain him at perfection. The fact that a race of animals exists in a locality is a strong argument for its continuance. Safe and reasonable as is the opinion above stated, notable exceptions to its truth might be given. Thus, the shorthorn has made his way to the detriment of many native established breeds. The Leicester and Shropshire sheep have supplanted many of the older ovine races, and at the present day there is a tendency for certain dominant and improved races of live stock to intrude into districts up to this time occupied by native breeds. All we demand is caution, as sweeping and ill-considered changes are liable to end in loss to the too-enterprising agriculturist.

CATTLE BREEDING

may be divided into the breeding of high-bred or pedigree stock and the breeding of good useful cattle intended for the production of beef and milk. The first division represents the breeding of animals with the object of improving the race generally; and the second, while it participates in the improvements effected by the first, has for its object the immediate supply of the consumer. In the first, a perfect form, fine quality, and unspotted lineage are essential; in the second, a "good sort" is all that is asked for—cows which give plenty of milk—healthy, growing young stock, and steers which will yield a good return for the food they consume. Such animals are very frequently the produce of ordinary "useful" cows and pure-bred shorthorn bulls. We have already given sufficient space to the principles of breeding pure-bred stock, and we now turn to the management of more ordinary cattle, such as are to be met with on all well-managed mixed husbandry farms.

The calf is affected, previous to its birth, by the treatment of its mother. Cows should not, therefore, be milked when within six weeks of calving, if we wish to obtain well-nourished and well-grown calves. This first precaution having been enforced, we shall, without entering into all the difficulties incident to parturition, suppose the calf to be naturally ushered into the world. This important event usually takes place in the spring. Calves are dropped at all seasons of the year, but many reasons may be given for preferring the spring for this purpose. First, the young animal has the summer before it, and will have gained sufficient strength previous to winter to enable it to stand its rigours; secondly, the mother is brought into the best condition for yielding milk just when grass is most abundant. Where the farmer supplies the demand for new milk, he requires cows to calve at various seasons of the year; but where cheese is the staple produce of the dairy, summer is the only time during which the manufacture proceeds briskly.

The subject of bringing up calves is one on which much might be written, but our space being restricted, we are necessarily compelled to treat it with brevity. What, then, is the method to be adopted? We may allow the calf to suck its dam, a plan which has the recommendation of being natural; we may teach the calf to drink, and bring it up by hand on new and old milk; or we may adopt the system of feeding upon substitutes for milk, such as gruel or mucilaginous substances. Each of these plans has its advocates, and each must detain us for a short time. The writer objects to the first plan, unless in the case of high-bred stock, or of cattle which are intended to be forced forward from their birth and fattened at a few months old. Under any other circumstances this method is open to the following objections:—The quantity of milk the calf receives cannot well be controlled; the diet exclusively consists of new milk, and the thrifty farmer is debarred from introducing any other cheaper material, such as Iceland moss, linseed mucilage, and gruel, all of which are excellent foods for young calves. We must also remember that, where the land is poor, and where the yearlings and two-year-olds have to do as well as they can upon somewhat bare pastures, it is very questionable policy to pamper calves, and thus unfit them for the hard life which lies before them.

These considerations clearly point out the expediency of limiting the amount of new milk, and this can only be done by bringing the calf up by hand. Immediately the calf is born, it is removed to a suitable hutch or crib, and rubbed dry with straw. It should receive its first meal immediately after this operation, and during the first day it should be fed every four or five hours. The meals are speedily reduced to three, and afterwards to two per day, until weaning time. A calf requires to be taught to drink. Its natural inclination to suck is satisfied by placing one or two fingers of one hand in its mouth, while with the other hand the head is lowered, by gentle pressure on the crown, into a vessel containing milk, until the mouth of the animal is immersed. The sucking proceeds, and by gradually withdrawing the fingers, the calf is soon taught to drink. A very young calf is for this reason sometimes spoken of as a "finger calf." The following dietary for calves from birth to weaning is employed upon a well-managed farm in Northumberland with great success:—

1st day . .	1 pint of new milk every 4½ hours.		
2nd day . .	2 pts. in the morning;	2 pts. at noon;	3 pts. at night.
3rd day . .	3 ,, ,,	3 ,, ,,	4 ,, ,,
4th and 5th days,	4 ,, ,,	2 ,, ,,	4 ,, ,,
6th and 7th days,	5 ,, ,,	2 ,, ,,	5 ,, ,,
8th and 9th days,	6 ,, ,,	0 ,, ,,	6 ,, ,,
10th to 30th days,	8 ,, ,,	0 ,, ,,	8 ,, ,,
2nd month . .	8 (old milk) ,,	0 ,, ,,	8 (old milk).
3rd month . .	8 (old milk) ,,	0 ,, ,,	8 (old milk).

Eight quarts per day is thus the maximum amount of milk given, and the increasing appetite of the growing animal is satisfied by grass, hay, finely-chopped turnips, meal, ground cake, etc., which it soon begins to relish if they are properly introduced to its notice. Mr. Bowick, manager of Mr. Howard's (Biddenham) farm and herd, in an admirable essay on calf management, gives the following allowances of milk as requisite for calves:—

1st week, with the dam, or 4 quarts per day, given in two meals.
2nd and 3rd weeks—5 to 6 quarts, given in two meals.
4th and 5th weeks—6 to 7 quarts, given in two meals.
6th to 12th weeks—8 quarts, given in two meals.

"If really good, creditable beasts are wanted—such as will realise £25 per head from the butcher when turned two-and-a-half years old—a little cake or meal will be found a desirable investment." Further, Mr. Bowick makes the following alterations from new to old milk:—New milk is given the first fortnight; the third week skim milk is substituted to the extent of one-third of the allowance; and at the fourth week the new milk is reduced to one-half, and boiled linseed gruel is added,

five pounds of linseed being enough to provide seven gallons of gruel, and to suffice for five calves. Mr. Bowick recommends the plan of tying up calves, but the more general and healthy plan is to keep them in cribs or hutches in a light, well-ventilated building. The cribs vary in size from 4 ft. × 4 ft., and 4 ft. high, to 4ft. × 8 ft. × 4 ft., and are "sparred" with slips of tile-lath and provided with a small wooden wicket to afford access to the calf. The floors of the cribs may be earth, but the passage between them should be flagged or of asphalte (Scott Burn). Each calf crib must also be provided with a trough and rack.

Mr. Henry Ruck (Cricklade, Gloucestershire) described an excellent plan for bringing up calves with a minimum quantity of milk, which he had successfully carried out for some years. His experience was communicated to the Cirencester Chamber of Agriculture, and was reported in the *Agricultural Gazette* of August 25, 1866. Calves are purchased at ten days old for about 30s. each. For the first three or four days they receive a milk diet, after which their food is gradually changed to a prepared gruel. This gruel is made as follows:—First, seven pounds of the best bruised cake is stirred into two gallons of hot water; next, two gallons of a watery infusion of hay (hay tea), diluted with a further addition of two gallons of water, is added; lastly, seven pounds of mixed meal, formed of equal parts of oat, wheat, barley, and bean meals, and the whole is well incorporated by stirring. More concisely, the gruel is composed of the following ingredients:—7 lbs. of linseed cake, 7 lbs. of mixed meal, 2 gallons of hay tea, and 4 gallons of water. Two quarts of this fluid, with two quarts of water, are given to each calf twice a day, and the young animals thrive well upon it at a cost of from 1s. 3d. to 1s. 6d. per week. The foregoing directions must be supplemented by very careful supervision, a point which is strongly insisted upon by Mr. Ruck, otherwise failure will be the inevitable result. Calves will be out at grass during their first summer. After weaning they may receive a small quantity of artificial food—say 1 lb. of linseed cake: they should be provided with a shed during the hot summer months, and as the nights become cold, towards the middle of October, they will be brought into fold-yards.

MANAGEMENT DURING THE FIRST WINTER.

Too often a starvation system has been followed in the wintering of young cattle. While we discountenance pampering, we certainly recommend a liberal plan of feeding, regulated by the quality of the grass land into which the young stock will be turned the succeeding summer. It would be the height of folly to feed young animals with expensive forcing foods in the winter, and then to turn them into poor bare pastures in the summer. Rather let us keep the future in view, and secure a steady, healthy growth from first to last. The usual system is to place the stirks in a fold provided with a shed; to give them a fair allowance of roots, barley or oat straw, and hay, cake, or corn, according to the liberality of the farmer who owns them. Mr. Ruck recommends 1 lb. of cake, 2 lbs. of crushed barley, cut straw, and pulped mangold as sufficient. Mr. Lawrence, of Cirencester, has given 1 lb. of cake and meal and 15 lbs. of pulped roots mixed with chop (cut straw). These figures sufficiently indicate the quantity of food which may be given. The stirks, meanwhile, should be well cared for, regularly fed, gradually changed from poorer to richer fare, supplied with fresh water, and placed in warm, dry, well-ventilated, quiet sheds. With such feeding and surroundings, every particular of which is of great importance, we may hope to see well-grown, healthy yearlings, ready for turning out to grass in the spring.

MANAGEMENT DURING THE SECOND SUMMER AND SECOND WINTER.

This is simple enough. The second summer the young cattle will be out at grass. The second winter they will again be brought into the yards, and fed according to the purpose for which they are intended. If to run once more on poor land during their third summer, straw and a few turnips will suffice; if to be brought out as "fresh beasts" and offered to the graziers of good land, then they will be proportionately better "done." Straw and about 3 lbs. of rape cake will keep such cattle alive and healthy. The "Farmers' Calendar" (page 46) recommends 1 lb. to 2 lbs. of linseed meal and a small handful of salt to be added to 1 gallon of water and boiled in a copper. The resulting liquid is then poured over chaff, at the rate of 1 gallon to 2 bushels, and this is given to the cattle twice a day. The two-year-old cattle, after their third summer's grass, are generally disposed of at two-and-a-half years old, to be fattened in the winter, and brought out as fat cattle at or about three years old.

THE LATHE.—XI.

By Henry Northcott.

HAND-TOOLS FOR TURNING IN VARIOUS MATERIALS.

The hand-turning tools for soft woods consist of gouges and chisels. The gouge is shown at Fig. 32, and the flat-edged chisel at Fig. 33. With tools of this sort almost any kind of work can be produced when one knows how to use them. They are employed of many different sizes, and sometimes the flat chisels have different angles for more convenient application to the work; but these two tools are the soft-wood turner's most powerful auxiliaries. Indeed, they may be called the only soft-wood turning tools, because they are not only applicable to almost every kind of soft-wood turning, but they are in form, cutting edges, and mode of using, quite different from all other tools employed by the wood-turner. It may sometimes be advisable to use a tool of some other shape; but in all such cases the tools will be similar to those used for turning hard woods, with the cutting angle ground rather more acute. The gouge is used for taking off the first or main portion of the superfluous wood, technically termed "roughing down." An expert workman will very considerably reduce the size of a piece of wood at a single cut, and will raise a heavy shower of shavings which fly in all directions from the tool's edge. He will first roughly and rapidly reduce the article in this way to nearly the required shape, and then with a sharper tool of the same sort, and with more care, will go again over the turned surface, and with a few light cuts leave the whole article very nearly the proper shape and size. The chisel is then carefully applied to the work, and the comparatively rough surface left by the gouge is replaced by the smooth glossy surface of the well-turned article.

The hand-turning tools for hard woods are shown at Figs. 34 to 70. These tools are nearly all known as chisels, and are only distinguished by the shape of the cutting edge. Fig. 34, for instance, is the flat chisel; Fig. 35 the diamond-point chisel; Figs. 37 and 38 the round-nosed and half-round chisels; and so on with the others. Fig. 34 is chiefly used for turning cylindrical articles; Figs. 35 and 36 for turning angular shapes, corners, and flat surfaces. Figs. 37 and 38 are useful to produce curved forms, round grooves or channels; and Fig. 37 is also generally used for roughing down the harder woods. Fig. 39 is not a very useful tool, because it will only produce one particular form and shape. Fig. 40 is rather more useful. The two last are employed to produce round beads or mouldings. Figs. 42, 43, and 44 are sometimes called "parting" tools. They are useful for very small work, but chiefly for "parting," or cutting off pieces of work from the main cylinder or log. Figs. 45, 46, and 47 are termed "internal tools," as they are chiefly used for turning out holes, and for hollow work. Tools of this sort, but with a keener cutting edge, are sometimes useful for turning soft woods. Figs. 48 and 49 are "holing tools." They act more like drills than turning tools; but they are very useful instruments. Figs. 50 to 54 are chiefly useful for internal work and for side cutting. Some of them cut towards the right, and some to the left, and they are distinguished as right-handed or left-handed side tools according to the direction of the cutting edge. Figs. 55 to 61 are cranked tools, and are very useful for turning internal grooves, and otherwise shaping work not accessible to the straight tools. The hard-wood turner uses them of several sizes, and cranked towards both the right and left hand. Of these tools Figs. 56, 57, 58, and 61 are the most often in request. Figs. 55, 59, and 60 are less useful. Figs. 62, 63, 64, and 65 are also very useful tools. They are employed for turning fancy work, and for touching out corners difficult of access. Figs. 66 to 70 are beading or moulding tools. They are used for producing definite forms or set mouldings upon the turned articles. Any of these forms can, of course, be produced by the ordinary turning tools, and it

is only when many articles of the same shape are required that it becomes worth the workman's while to obtain these special tools for the work. Mouldings produced by these tools are, of course, more correct, and more likely to be uniform, than if the curves were separately turned out with the ordinary tool.

The figures show most of the tools in general use, but many of them may be dispensed with altogether: indeed, it is surprising how few tools some workmen use, and it is very often the case that the largest assortments of tools and instruments are found in the workshops of the least efficient turners. For soft-wood turning the gouge and flat chisels (Figs. 32 and 33) are quite indispensable. For hard-wood turning Figs. 34, 35, 37, 44, 45, 47, 48, 56, 57, and 58 are the most necessary tools. Many of the others are sometimes very useful, but most of them can be dispensed with. For fancy and ornamental turning it is often necessary to have tools made expressly to suit the work, and such tools are generally useless except for such work. Some of these special tools will be illustrated in connection with the work they are designed to effect, and these will be sufficient to indicate how special tools for other work should be formed.

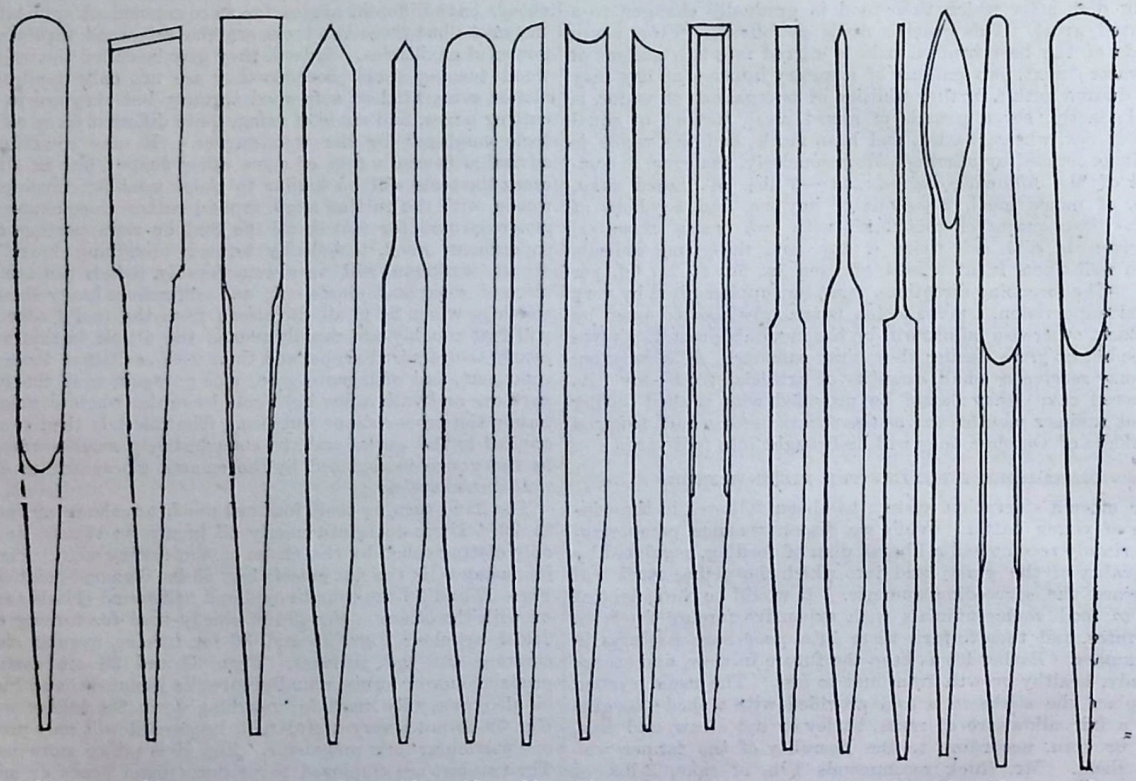
The tools used for turning wrought iron and steel are given at Figs. 71 to 76. Figs. 71 to 74 are used for roughing down the article. Figs. 75 and 76 are side tools for turning ends and side surfaces. The finishing cuts are usually taken by chisels somewhat similar to Fig. 42, but made much deeper and stronger, to withstand the increased strain put upon them.

Fig. 74 is also used for taking the roughing cuts off brass articles, and the finishing cuts are taken with the tools shown at Figs. 77 to 81. These tools in outline are much the same as those used for turning hard woods; but the angle of the cutting edge is, in the tools for brass-turning, made more obtuse than in the tools for wood. The blades also are made stouter towards the handle, and the steel is tempered rather harder. In addition to these tools, the brass-turner occasionally requires the use of cranked tools, and special tools of much the same shape as those already given amongst the wood-turning tools, but with a cutting angle adapted to brass, and which is about 90 degrees.

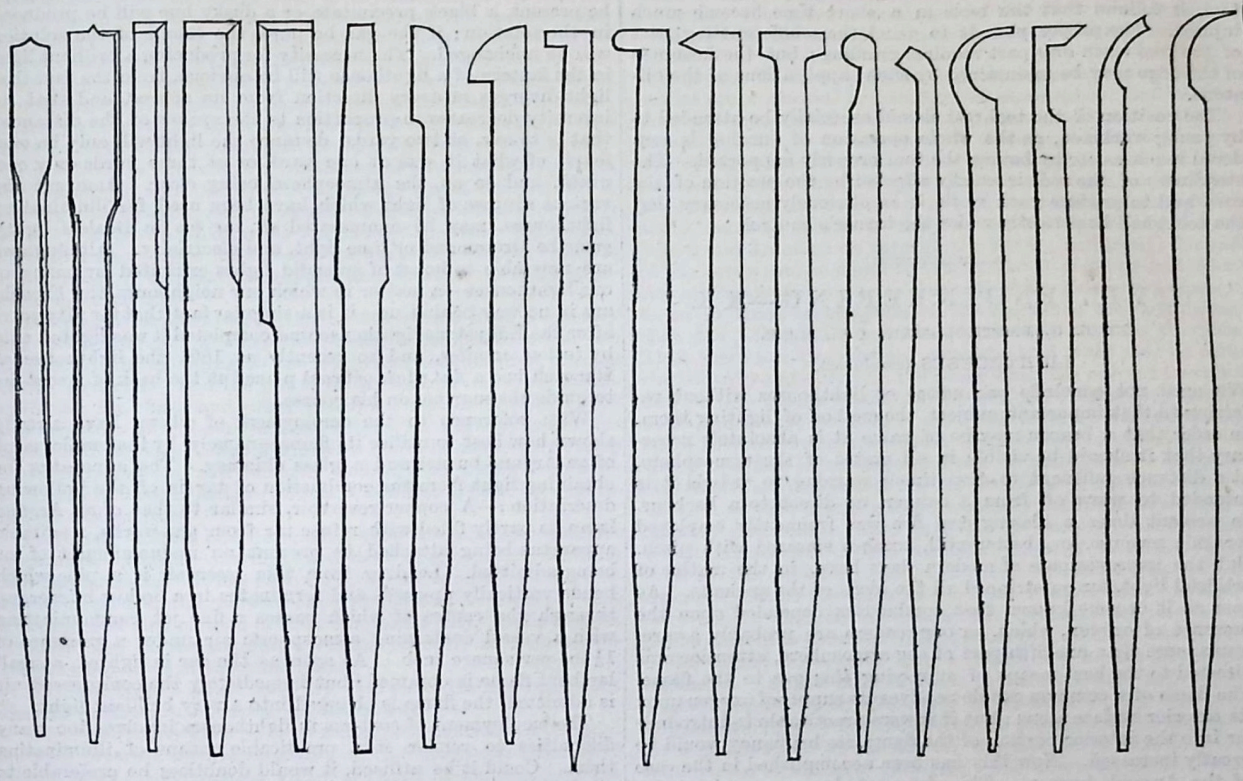
Most of these tools are used after the same manner, but the efficient use of some of them is much more difficult to learn than of others. The two soft-wood tools are truly cutting instruments. The tools for turning hard woods and brass are scarcely of this class, as their action upon the materials is more akin to scraping than cutting. Some of the turning tools for iron also act incisively. Figs. 71 to 76 are of this class; but the tools used upon cast iron act chiefly as scraping tools. As a rule, the tools which act by cutting are more difficult to use than those that act by scraping.

The gouge and flat chisel for soft woods are held with the cutting edges above the centre of the work, and with the handles of the tools lower than the cutting edges. The hard-wood and brass-turning tools are nearly all held with the cutting edges just level with the lathe-centres, and with their handles also on about the same level. All the tools are supported against the cuts by a tool-rest of some sort, and this support is generally placed as near the work as possible. The tools are held by both hands, and generally the left hand is employed to guide the edge along the work in the required direction for shaping it, whilst the right hand is employed to regulate the height and inclination of the tool's edge, and the depth of its cut. It should be explained that the term "scraping," applied to describe the action of some of the tools, is, to some extent, an incorrect term, or rather, a term likely to be misunderstood. All of the tools act by cutting the substances they work upon, but in some of them the incisive action is more marked than in others. The chief points to be observed in the use of hand-turning tools are, first, that the tools shall be properly shaped, and kept in good order; second, that the tool-rest or support shall be placed near the work, so as to reduce the leverage acting against the workman as much as possible; third, that the tools shall be maintained in proper position upon the rest, and kept firmly up to their work.

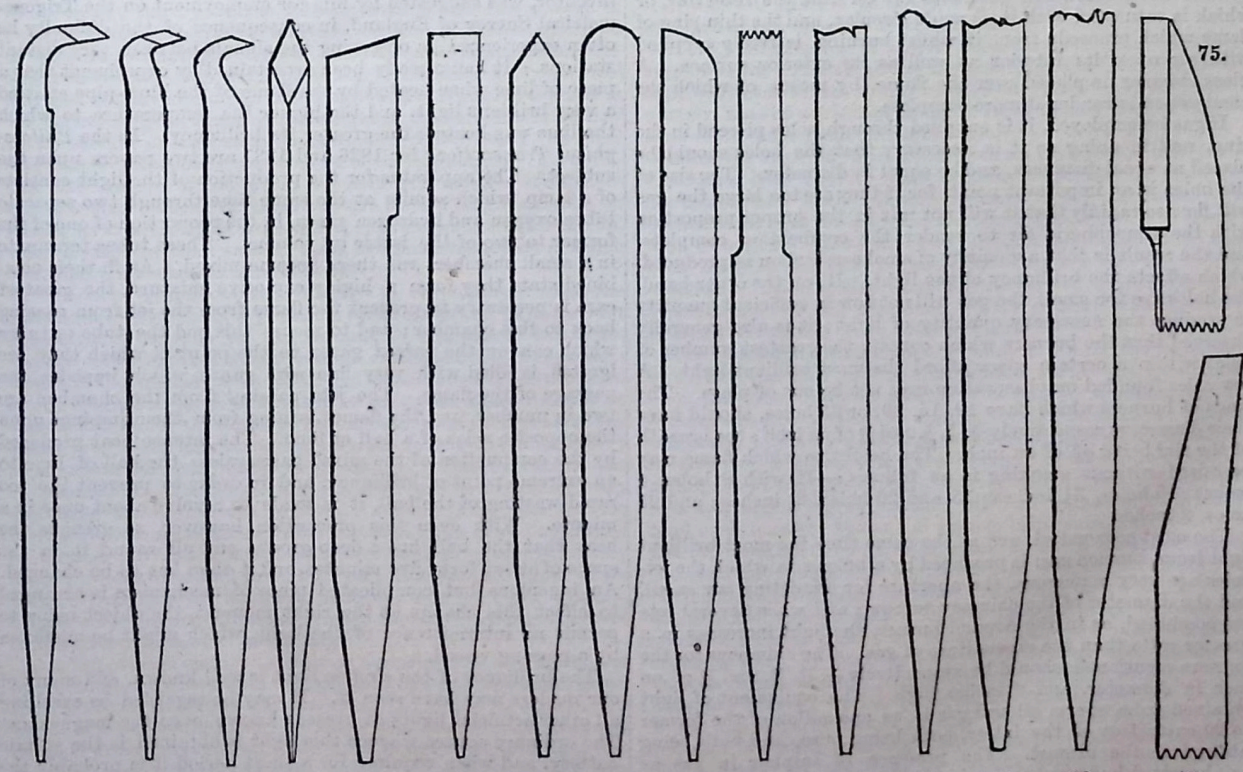
The first point is very frequently neglected even by old hands at turning. The tools are first of all, perhaps, properly shaped and in good order; but as they wear dull on the cutting edge, they are sharpened by removing a small portion of metal near this edge. And as no metal can be removed from the cutting



Figs. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47.



Figs. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65.



Figs. 71. 72. 73. 74. 77. 78. 79. 80. 81. 70. 69. 68. 67. 66. 76.

edge alone without gradually altering the shape of the whole tool, it follows that the tools in a short time become much injured. The proper plan is to grind the whole cutting part of the tool when *any* part requires grinding; but the keenness of the edge may be maintained by slight applications of the oil-stone.

The position of the tool-rest should especially be attended to by young workmen, as the whole operation of turning is rendered much easier by having the tool properly supported. The steadiness of the tool is chiefly affected by the position of the rest, and to produce good work it is obviously necessary that the tool shall be perfectly under the turner's control.

CIVIL ENGINEERING.—XX.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*concluded*).

We must not conclude our notice of lighthouses without referring to that important subject, the method of lighting them. In order that a beacon may be of value, it is absolutely necessary that it should be visible in all states of the atmosphere, at a distance sufficient to give timely warning to vessels it is intended to warn off from a danger, or direct to a harbour. In ancient times a blazing coal fire was frequently employed for this purpose, or, better still, torches smeared with pitch. But the improvements of modern days have, in the matter of artificial light, far outstripped all the ideas of the ancients. As soon as it became known that combustion depended upon the presence of oxygen, which, as our readers are probably aware, forms more than one-fifth part of the atmosphere, attention was directed to the best means of supplying this gas to the flame. The flame of a common candle receives its supply of oxygen upon its exterior surface alone; but if it were practicable to introduce air into the interior portion of the flame, its brilliancy would be greatly increased. Now this has been accomplished in the case of the Argand burner. This form of burner consists of a circular ring, around which the fuel is supplied. If it is intended to burn oil, the substance usually employed in lighthouses, the wick which abstracts the oil from the reservoir, or which is saturated with it, is made circular, and the thin ring of flame which proceeds from it whilst burning is freely supplied with air upon its interior as well as its exterior surface. A glass chimney is placed over the flame, by means of which the combustion is rendered more complete.

If gas be employed, it is supplied through holes pierced in the ring, and in doing so it is necessary that the holes should be placed at equal distances, and be equal in diameter. The size of the holes is an important point, for if they are too large the gas will flow so rapidly that it will not mix in the proper proportion with the atmospheric air to render the combustion complete, and the result is that a quantity of smoke or carbon is produced, which affects the brilliancy of the light. If, on the other hand, the holes are too small, the gas will not flow in sufficient quantity to produce the necessary quantity of light; it is also generally observed that the burners which contain the greatest number of holes within a certain space afford the most brilliant light. A few rules founded on observation may not be out of place. The rings of burners which have 10, 15, 20, or 25 holes, should have their diameters respectively $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{5}$, and $\frac{19}{20}$ of an inch; the breadth of the rim being $\frac{12}{100}$ of an inch. The height to which flame may be raised without smoking is as follows:—If with 8 holes, 4 inches; 10 holes, $3\frac{1}{2}$ inches; 15 and 20 holes, $2\frac{1}{2}$ inches; and 25 holes, 2 inches.

The most economical, and at the same time the most brilliant light from common gas, is produced by a burner in which the jet-holes are very numerous, the aperture for admitting air small, and the diameter of the chimney narrow; and when several jets are combined, as in the Argand burner, the light increases in a greater ratio than the expenditure of gas. The chimneys for the burners mentioned should be respectively $\frac{8}{10}$, $\frac{12}{10}$, $\frac{13}{10}$, and $\frac{15}{10}$ of an inch in diameter, and 6 inches high. The equivalent of light obtained from sperm oil and gas is as one gallon of the former to 29 cubic feet of the latter, both being pure, and both being utilised to the utmost. The presence of sulphur in gas as sulphuretted hydrogen is detrimental to the purity of the light produced by its combustion; this is readily detected by passing a stream of it through a solution of acetate of lead. If sulphur be present, a black precipitate or a dusky hue will be produced in the solution; if the gas be pure, the colour of the solution will be unchanged. The necessity for producing a brilliant light in the lantern of a lighthouse will be obvious, from the fact that light diverges in every direction from its source, and that its intensity decreases in proportion to the *square* of the distance; that is to say, at two yards' distance the light will only be *one-fourth* of what it was at one yard, or at three yards only *one-ninth*, and so on, the atmosphere being clear. Amongst the various sources of light which have been used for illuminating lighthouses, may be enumerated oil, tar (as in Beale's light), gas, the Drummond or lime light, and electricity. Although we are now able to boast of splendid lights exhibited by many of our lighthouses—a matter in which our neighbours, the French, are in no way behind us—it is a singular fact that for fifty years after the Eddystone lighthouse was completed it was lighted only by *tallow candles*, and so recently as 1801 the lighthouse at Harwich had a *flat plate of brass* placed at the back of a *coal-fire* to guide the mariner on his course.

With reference to the employment of oil, we have already shown how best to utilise its flame—namely, by the employment of an Argand burner and a glass chimney. The apparatus for obtaining light from the combustion of tar is of the following description:—A copper reservoir, similar to that of an Argand lamp, is partly filled with refuse tar from gas-works, a suitable apparatus being attached to prevent an undue amount of tar being admitted. Leading from this reservoir is a pipe which bends vertically upwards and terminates in a hollow burner, up through the centre of which passes a fine jet communicating with a vessel containing atmospheric air under a pressure of $1\frac{1}{2}$ lb. per square inch. As soon as the tar is lighted, a small lambent flame is obtained; but immediately the compressed air is admitted, the flame is changed into a very brilliant light.

The employment of coal-gas in lighthouses involves too many difficulties to render it a practicable means of illuminating them. Could it be utilised, it would doubtless be preferable to oil, both in economy and brilliancy. Equal, or indeed greater difficulties present themselves in the employment of the Drummond light. This exceedingly brilliant light, called after its inventor, was suggested by him for employment on the Trigonometrical Survey of England, in consequence of the difficulty he often experienced in observing the signals between very distant stations. It had already been ascertained by experiment that a piece of lime when heated by the flame of the blow-pipe emitted a very brilliant light, and the higher the temperature to which the lime was heated, the greater its brilliancy. In the *Philosophical Transactions* for 1826 and 1831 are two papers upon the subject. The apparatus for the production of the light consists of a lamp, which admits at the same time through two separate tubes oxygen and hydrogen gases, in the proportion of one of the former to two of the latter by volume. These tubes terminate in a small chamber, and there become mixed. As in their combined state they form a highly explosive mixture, the greatest care is necessary to prevent the flame from the jet from passing back to this chamber; and to secure this end the tube or tubes which convey the *mixed* gases to the point at which they are ignited, is filled with very fine wire gauze, which impedes the passage of the flame. The jets passing from the chamber are two in number, and the flames issuing from them impinge upon the opposite sides of a ball of lime. The intense heat produced by the combustion of the mixed gases raises the ball of lime to an extreme point of brilliancy, and in order to prevent the too rapid wasting of the ball, it is made to revolve about once in a minute. With even this precaution, however, so great is the heat that the ball has a deep groove cut all round it in the space of about forty-five minutes, and it then has to be changed. An ingenious but complicated piece of mechanism is arranged to effect this change at the right moment, the object being to permit no intermittence of the light, which might be mistaken by a passing vessel.

The brilliancy of the *electric* light is well known, and many of our readers may have seen it. It may be regarded as excelling all other artificial lights at present known, even the magnesium. The ordinary source whence this light is obtained is the voltaic battery, and when required for a short period it is probably the most economical. The mode of obtaining the light from the battery is simply to terminate the wires which lead from its

extremities by carbon prepared in a peculiar manner, and shaped like a pencil of ¼ inch square. The circuit of the battery being completed by contact of the points, they may be withdrawn a certain distance apart, and the electric flame will continue to burn through the space of air between. Care must be taken not to withdraw the points too far, otherwise the flame will cease, and contact must be again made before it will re-appear. The *distance* to which the points can be separated without extinguishing the flame is dependent upon the *number of elements in series* in the battery, and the *volume* upon the *size* of the plates. A self-regulating apparatus is usually employed with the electric light, by which the distance is maintained between the points, allowance being made for the combustion of the carbon. We do not consider it necessary to explain the character of this apparatus in detail now.

The employment of electricity derived direct from a battery has its objections. The expense is very considerable when the time is prolonged, owing to the waste and consumption of some of the materials; and the power of the battery is by no means uniform: for these and other reasons attention has been paid to *magnetism* as a source of electricity. To Faraday is due the merit of discovering that magnetism could be made to develop electricity, and the now common medical coil which is sold by surgical instrument makers affords a familiar type of an apparatus for the purpose.

Professor Holmes has designed a very powerful and effective apparatus, by means of which he obtains an exceedingly brilliant and regular light. It has been employed at Dungeness for a considerable period, and more recently at the South Foreland. The advantage of this method of obtaining electricity for lighthouse purposes lies in the *constancy* of the current, so long as the helices revolve with the same speed.

To quote from a paper read by Professor Holmes before the Society of Arts, in December, 1863, he says:—

"The electricity derived from a magnetic machine is induced in coils of wire, by the changing of the magnetic polarity of pieces of soft iron enclosed within the coils or helices; and the quantity or intensity of the induced current depends, first, on the amount of magnetism induced in the soft iron; secondly, on the facility with which the poles of the magnetised soft iron can be reversed; thirdly, on the velocity with which the change of polarity takes place; and, fourthly, on the length and diameter of the wire forming the helices. The amount of magnetism induced in the soft iron depends on the size and force of the steel magnets employed, and on the weight and softness of the iron in the helices; but in practice the weight of the soft iron is limited by the weight of the steel magnets, for if too heavy the steel magnets will be slowly deprived of their magnetism. To facilitate the change of the poles, the soft iron cores of the helices are not solid pieces of iron, but are tubes, single, double, or treble, as it is found by experiment that the same weight of iron, when divided in this manner, loses or takes magnetism in much less time than when in a solid form."

"There is a limit to the velocity to be employed when the maximum of electricity is required, for this reason. The amount of electricity depends on the amount of magnetism taken up, and the soft iron takes time to become saturated with magnetism: hence, if the velocity with which the cores move from the poles of one magnet to those of another be too great, there will not be sufficient time for the cores to become saturated. But since the quantity of electricity increases with the velocity, it is necessary to ascertain this maximum point exactly, either by experiment or calculation. The length and diameter of the wire must vary according to the current required; a short thick wire for the helices represents a battery with plates of large area, but limited in number; whilst a long thin wire will represent a battery having plates of small area, but very numerous. From these facts certain known laws are deduced, founded upon which a magneto-electric machine can be made capable of giving a current of any given amount of electricity."

An important feature in Holmes's machine is the method of converting every alternate current into one and the same direction with the intermediate currents. In order to explain this point, it is necessary briefly to state that the electrical currents induced from magnets are very brief in duration, and that the currents are obtained at each change of polarity in the iron cores within the helices, and moreover that the direction of the successive currents so obtained is alternately reversed. The result of this reverse character in the currents is, that one tends to destroy the other if produced in the same wire, unless by some plan all the currents can be thrown in the same direction in that wire.

Professor Holmes explains his arrangement thus:—"The helices are connected in two, four, or more series; and in doing this, care must be observed that the direction of the coil of every alternate helix is in an opposite direction—that is, if one is wound right-handed, the next is wound left-handed; or what amounts to the same thing, supposing all wound in the same direction, then the two inner ends of the helices of, say, Nos. 1 and 2 must be joined to the two outer ends of the helices of Nos. 2 and 3, and so on through the series; and lastly, the ends of the series are soldered to two insulated discs against which two springs press. . . . One half of the helices are arranged so as to arrive on the poles of the magnet at the same instant that the other half are exactly midway between the poles. Thus there are two distinct currents, and what may be called the 'dead' point—that is, the point when the current inverts in one series—occurs exactly at the time when the other current is at its maximum, so that if now the inverted currents can be again inverted in both of these distinct currents, and the two which now flow in one direction can be united as one compound current, it is evident that the result will be a current nearly as uniform as that from a galvanic battery, with the advantage of equable continuity. This is done by the two commutators, which consist each of two insulated rings of metal, of such a form at the periphery, that two rollers or rubbers change sides from one disc to the other at the same instant that the current is reversed; then, by combining the two commutators, a compound current is obtained which produces *a constant white light*."

We cannot now enter into a description of the professor's regulator. Suffice it to say that he has succeeded in producing a most intense light, which may be maintained for any length of time, which does not require to be trimmed or extinguished for a second, and which has all the steadiness and uniformity required for lighthouse purposes. The intensity of this light has a power of penetrating haze only equalled by the sun, and its cost, light for light, is far less than the cost of oil.

We regard this invention of sufficient importance, in connection with our subject, to render any apology for having devoted so much of our space to it unnecessary.

It only remains for us now to describe the methods which are employed for utilising all the illuminating rays from the flame—from whatever source it may be derived—for the object intended, namely, that of projecting a ray of light upon a belt of water at a given distance from the lighthouse.

Since the rays of light issue from an illuminated point in *all* directions, it is obvious that a great proportion of these rays are useless and wasted if only required in *one* direction, unless some means can be adopted for bending or *refracting* them in that direction. There are two distinct methods which have been adopted for this purpose, the *Catoptric* and the *Dioptric* systems. There is also what may be termed a third system, in which these two are combined. This is the *Catadioptric*, or, as some call it, the *Holophotal* system.

The Catoptric arrangement is that in which the rays which form the one half of the illuminated sphere are thrown back upon the other half by means of a parabolic reflector. This system was first applied at Dieppe, by Borda, in 1784; although reflectors, probably spherical, had been employed at Marstrand, in Sweden, a short time previously. A first-class catoptric arrangement consists of, say, three sets of Argand burners, three in a set, with a highly polished silvered parabolic reflector behind each burner; the entire system being caused to revolve, by the intervention of clock-work, round a centre, the space between the sets producing the occultation or eclipse necessary, supposing the light is intended to be a revolving one. The reflectors are of sheet copper, plated in the proportion of six ounces of silver to sixteen ounces of copper. They are moulded to the requisite form by beating them with mallets and hammers of various forms, and are frequently and carefully tested. After they are formed to the paraboloidal curve, they are stiffened round the edge by means of a strong bezzle. The form of the reflector is tested by trying a burner in the focus, and measuring the intensity of the light at various points of the reflected conical beam.

The Dioptric arrangement is that in which the rays issuing

from the flame are collected and refracted in a given direction by a lens placed in front of the light. So far back as 1752 a lens was tried at the South Foreland, but abandoned, owing to some mechanical imperfection. In 1819 Fresnel constructed a lens which may be said to have produced a revolution in the method of illuminating lighthouses. Previous to the date mentioned, Condorcet in 1773, and Brewster in 1811, had suggested the idea of *building up* a burning lens in separate pieces. This was the plan which Fresnel devoted himself to perfect in order to apply it to lighthouses, he being at the time secretary to the French Lighthouse Commission, under the presidency of Arago. In a plano-convex lens the rays of light falling upon one of its faces are refracted in lines *nearly* parallel to its axis, but the parallelism becomes less the further the rays lie from that axis, and this aberration is excessive when the lens is very large. It was to obviate this defect, and obtain full command over *all* the rays falling upon the lens, that Fresnel designed his lens. In Fig. 45 we give a diagram of one of Fresnel's lenses in section, showing its action upon the rays it receives. A B is a section of the lens, which it will be seen consists of many separate pieces or rings concentrically surrounding a small central lens L, the whole having their flat surfaces arranged in one plane. S is the source of light, the rays from which falling upon the system of rings, are refracted in parallel lines A A′, L L′, B B′, according to a well-known law. The advantage gained by a Fresnel lens is twofold. In the first place, by combining calculation with experiment, the precise curve of each separate ring is so arranged as to ensure *perfect* parallelism in the refracted rays. Now supposing it practicable to grind a plano-convex lens to such an exact curve as that the refracted rays should be perfectly parallel, we should obtain a lens whose thickness in the centre would be several inches, and the absorption and consequent loss of light by transmission through this mass would be serious. Here then we have the second advantage gained by a Fresnel lens. Looking at it irrespective of the curve, we may regard a Fresnel lens as a plano-convex lens cut into slices parallel to the plane surface, having a disc cut out of the centre of each slice. Our meaning will be better understood by a reference to the diagram (Fig. 46).

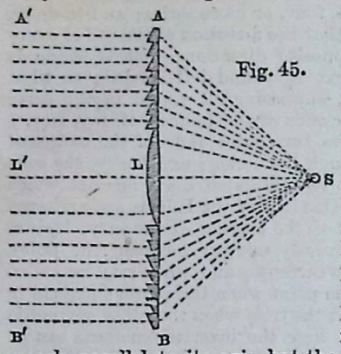


Fig. 45.

Fig. 46.

Let A A′ represent a section of a plano-convex lens, and imagine it cut into slices by the lines B B′, C C′, D D′, E E′, parallel to the face A A′. Now, since the whole of the refractive action of the entire lens lies in the angle formed by the two lines A A′, A O A′, of which the latter line is curved, it follows that if the various slices be separated from each other, their respective faces being kept parallel, there will be in each slice a central portion bounded by the point at which the curve commences, of which the two faces are parallel, as shown in the diagram by the shaded portions, and to which, in consequence of the parallelism, no refractive action is due. The whole of this portion can therefore be cut away, and the rim remaining—almost precisely similar to a quoit in shape—will exert just as large a refractive action without the central disc as with it, with the advantage of dispensing with a mass of glass whose only effect is to absorb light. If then in each slice the central discs be removed, the several rims remaining can be pushed forward, so that they assume the position shown in Fig. 45.

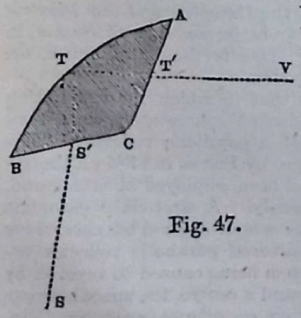


Fig. 47.

In a light of the first order, the central lens is about eleven inches diameter, with a focal length of rather more than 36 inches, and the concentric rings surrounding it (the slices without their discs) gradually decrease in breadth from 2¾ to 1¼ inches as they increase in diameter. A lens of this description, made of crown glass, will possess a refracting surface of about 1,300 square inches.

A very brief allusion to the *Catadioptric* arrangement is all we can afford space for. This, as its name implies, combines the Dioptric and Catoptric systems in one. The diagram (Fig. 47) will illustrate the arrangement.

Let A B C represent the section of a catadioptric ring, and S the source of light. The ray S S′, falling upon the surface C B of the ring, is refracted at S′ in the direction S′ T; it then becomes completely reflected at T on the curved surface A B, in the direction T T′, and finally emerges in the horizontal line T′ V.

It is easy to perceive that if due care be taken in the grinding and fixing of these rings, they may be so arranged as to *gather up*, so to speak, *all* the luminous rays from S, and throw them into a horizontal direction.

FISH CULTURE.—X.

By Greville Fennell.

OYSTER BREEDING, REARING, AND FEEDING.

Very much of late years has been written upon oysters and their culture, more especially since the great failures around Great Britain and Ireland, and on the Continent, where miles and miles of hitherto prolific parks, both natural and artificial, existed, have become, from various causes, either wholly unprolific, or entirely depleted.

It would be therefore a somewhat profitless work, more particularly where space is of value, to go back for information to books and documents which treat of the past history of these once famed oyster parks as a permanent success. We must therefore take as our guide the latest most reliable authority upon this interesting subject—the Report of the Commission appointed to inquire into the methods of oyster culture in the United Kingdom and France, with a view to the introduction of improved methods of cultivation of oysters into Ireland. The Commission was an unpaid one, composed of J. A. Blake, Esq., M.P., George William Hart, Esq., T. F. Brady, Esq., and Francis Francis, Esq.—the latter gentleman bringing his long practical experience to bear upon the inquiry. The instructions to the Commission are very discouraging upon the subject of oyster culture, more particularly in Ireland, it stating that in that country, out of nearly ninety licences granted by the Board of Works for oyster planting, which embrace an area of about 15,000 acres, scarcely half a dozen can be said to be successful. This is the more surprising, as Ireland is admittingly well calculated for the successful prosecution of *ostreoculture*. The favourable temperature of the sea, the large inlets and bays on the western coast, containing banks where oysters are already found in great numbers, the habits and tastes of the coast population, all show that this most valuable industry might be prosecuted with great success. The Commission was required to visit the principal places in France, England, and Ireland, where oyster cultivation is, or can be, carried on: they were to examine the best authorities upon the subject, and endeavour to ascertain the causes which have led to the many failures which have been experienced.

The young of the oyster, when perfectly formed, attach themselves immediately to the first clean, hard substance they meet with. It has been ascertained that the spat floating in the water for several days is that which from some cause has been ejected before maturity: such spat forms a large proportion of the whole, and during the time in which the spat is free, and is becoming fit for attachment, it is carried by tides and currents to great distances, is devoured by countless enemies, or is driven upon muddy and otherwise unsuitable ground, and so perishes. Under the most favourable circumstances, the proportion that never attaches is very considerable. In a natural state the oyster remains attached, during its lifetime, to whatever object it first adheres to; but after accidental removal it will sometimes again adhere to substances with a hard and tolerably clean surface. To save the bulk of the spat when free is the great object of oyster culture. It may be here stated that the young of all mollusks are apparently free for a longer or shorter term; of this fact the cockle, mussel, winkle, and balanus tribes afford proof.

In the British waters, and those of France, spatting usually takes place when the parent oyster is three to four years old, although it is not uncommon to find oysters milchy at a much earlier period. It has not been clearly ascertained how often during life breeding takes place, but there is no reason to suppose that it does not frequently occur in the lifetime of the same oyster, although it is believed that not more than 10 per cent. of the stock on any bed will usually spat during any one season. As oysters, however, from various causes, have been known to spat very late in the year, it is impossible with accuracy to state the proportion of full-grown oysters that breed annually. The young oyster, when sufficiently matured, rises immediately to the surface upon its emission from the parent, after which it adheres to the first clean hard substances it meets with: this motion is effected by what is termed a swimming pad (Figs. 21, 22, 23), but which is, in truth, but the protruded lobes of the mantle, and not an organ specially formed for locomotion, seeing that by it the shell is secreted. It is by this organ also that the oyster attaches itself, and this, too, in the same way that it forms its shell. Swimming with open shells, and extended mantle uppermost, on meeting with a clean, hard substance, it remains in close contact with it, and secretes over that part of the substance which it touches a coating of the same material of which its shell is formed. The first coating is followed by other layers, and so the once free oyster becomes

Fig. 21.

Fig. 23.

Fig. 22.

SWIMMING PAD OF THE YOUNG OYSTER.

fixed, and by a repetition of the process from time to time the necessary increase of shell is made to meet the requirements of the fish. By the same means, also, young or adult oysters, it is said, re-attach themselves to stones or other substances when removed from the places to which they first adhered. That oyster-spat invariably rises when first emitted is a fact to be appreciated in cultivation.

The nature of the bed or soil on which the oyster rests is a matter of the greatest importance, conferring as it does upon the oysters there bred or deposited special flavour or other qualities distinguishing them from all other oysters in adjacent grounds; and this influence prevails to so great an extent that dredgemen can in a fog or dark night readily recognise their position by the shape, size, or colour of the oysters brought up by the dredge; and although the distance between such beds is often small, they are enabled accurately to steer for the harbour from information of this peculiar kind. The nature of the soil is important in another aspect. Many circumstances highly favourable to the growth and fattening of oysters are the reverse for successful breeding.

Growth and fattening will proceed where there may be a large amount of fresh water and a strong current: the former would prove prejudicial to spatting, and the latter tend to prevent the adhesion of spat—at least in the locality at which it is voided.

Good spawning grounds have, on the other hand, been found less suitable for purposes of fattening—pure sea-water, and a clean bottom, essentials for successful spatting, not being always advantageous for the other purposes; hence it is usually found in rivers and estuaries that oysters breed better at the mouth, and fatten best higher up. There are, however, instances where the two processes are found to thrive simultaneously on the same banks.

The present diminution in the supply of oysters appears to have commenced some twelve or fourteen years ago. Since that period a greatly increased demand for oysters has resulted from the greater facilities of transport to places where previously fresh oysters had seldom reached. Another circumstance has also added considerably to the demand—viz., the more frequent use of oysters, owing to the fashion prevalent both in England and France, among the wealthier classes, of consuming them at almost every meal. This materially enhances the price, and has led to a vast increase in dredging. In 1855 the price of native oysters was 42s. per bushel; and in 1870 it was £8 to £9, while in 1872 it is £10 to £10 10s. A similar rise has taken place in seconds; while commons, in 1855, were 13s. to 14s. per bushel, they were, in 1870, 18s., and in 1872 are 20s.

Considerable difference of opinion exists as to the cause of this decrease in oysters, some authorities contending that it is altogether due to over-dredging, others to failure in the natural production of spat. There is no doubt, however, that the principal cause of the scarcity is attributable, both in France and England, to over-dredging; and this we can deal with, and to a certain extent counteract its effects, by wise legislation.

No better illustration, says the Report, can be given than the advantageous position which Ireland occupies when compared with either of the other countries. That her natural beds have suffered much less from exhaustion may be attributed in a great measure to the enforced close time and other salutary regulations made by the Commissioners of Irish Fisheries, which are not in existence in England, and only lately came into operation in France.

The oyster fisheries may be divided as follows:—Firstly. Natural banks, where, without any action on the part of man, oysters are propagated. Secondly. Banks partly natural and partly artificial, as in the rivers of Auray and other places in France, and of Essex and other places in England, where the production is aided by laying down fresh cultch (oyster-shells, tiles, stones, etc., for the oysters to adhere to) and stock, and keeping the beds clear of dirt and vermin. Thirdly. Foreshore cultivation, where the spat from oysters on natural banks is saved or caught on collectors placed for that particular purpose. Fourthly. The method of cultivation in enclosed spaces, such as Lake Fusaro, in Italy; at Hayling, the Isle of Wight, and other places.

The process of collecting oyster spat on stones, etc., has been practised at the Isle of Oléron for upwards of half a century, without attracting much attention—a fact which has not been previously noticed by any of the writers upon oyster culture up to the appearance of the Report of the Commission, it having been erroneously supposed to have originated at the Île de Ré; whereas the park system, which Hyacinthe Bœuf introduced into that island, was but a modification of the system followed at Oléron. Bœuf's discovery is said to have been altogether accidental, arising from the storing oysters within a small stone enclosure, and finding some time afterwards that a large quantity of spat had adhered to the stones. Encouraged by this, Bœuf, in the ensuing year, made a larger enclosure on the foreshore, and laid down more oysters and stones. The result was most successful, and many of his neighbours seeing this, engaged in like enterprises, and were so well remunerated for their trouble and outlay that an extensive cultivation on this plan was soon in operation on various parts of the shores of the island. These layings do not extend beyond low-water mark, and in most places the water is retained by small embankments. The results were much greater the first few years than they have been latterly; indeed, we hear that they have lately been nearly, if not wholly, destroyed by mud and sand. In 1859 the number of oysters was 157,500, valued at £126; in 1863, 5,650,259 oysters, valued at £4,535; and in 1867, 879,713 oysters, valued at £1,245.

The young oysters are usually removed from the stones at one year old. They are then placed in claires to grow and fatten, the time they remain in claires varying according to circumstances in the different localities.

The cause assigned for the recent failures was the improvidence of the concessionaires in selling off all the stock as soon as it was marketable, and leaving none from which to replenish the beds. But to a large extent it is probably also attributable to the stones, tiles, or other collectors being in a cleaner condition during the first year than they were afterwards, sufficient care not being taken to keep them free from mud and weed, without the observance of which precautions the adhesion of spat to collectors is very doubtful.

In our next paper on this interesting subject we shall call attention to some of the principal localities in which oyster-farming has been carried on, and the different modes adopted in this branch of shell-fish culture.

SHIP-BUILDING.—XIX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

BULKHEADS.

HAVING considered the three great subdivisions under which the principal parts of the structures of ships may be arranged —viz., the framing, skin, and decks—it will not be out of place to devote attention to some parts which can scarcely be included under either of these heads, although they are far from being unimportant. Chief amongst these stand "bulkheads," *i.e.*, the transverse or longitudinal partitions fitted in the holds of ships, whose principal features we will proceed to describe.

The bulkheads, or partitions in the holds of ordinary wood ships, are built almost solely with a view to convenience of stowage, their positions being determined quite independently of any considerations of safety, and their construction being very commonly such that they are not water-tight. There have, we believe, been some few cases in which a different plan has been adopted, the bulkheads being made water-tight and placed at comparatively small intervals apart; but this arrangement has only been had recourse to where an exceptional degree of safety was considered desirable—for example, in ships sent to the Arctic regions, and liable to serious injuries from the ice.

The general use of water-tight bulkheads dates no further back with us than the introduction of iron ship-building. Mr. Charles Wye Williams was, we believe, the first to recommend their adoption as a means of gaining increased strength and safety in iron ships; and the practice of fitting them has since become common, although the full advantages possibly derivable therefrom are not commonly obtained. In nearly all cases they are placed transversely, but in some vessels longitudinal partitions are also built. They are usually formed of thin iron plating stiffened by numerous angle-iron or T-iron bars, and thus made more or less rigid, adding greatly to the transverse strength of the ships. Of late years similar bulkheads have been fitted in composite ships, and also in some wood ships, mainly with a view to structural strength, but also as a means of increasing safety. With a wood skin, however, it is difficult to secure the thorough water-tightness at the edges of bulkheads which can be obtained in iron ships; nor is this equally necessary, because thick wood planking is less liable to penetration than thin iron plating, and because a leak in a wood bottom can generally be stopped more easily than one in an iron bottom. Fortunately, therefore, water-tight subdivisions can be made most efficient in the class of ships where they are most required.

Experience has furnished ample evidence of the great advantages gained by a proper arrangement of the bulkheads in iron ships, and of the dangers incurred by neglecting such arrangements. On the one hand, numerous cases are on record where iron ships have been kept afloat and safely navigated into port after receiving serious damage by collisions, grounding, fire, and other causes: on the other hand, many instances might be referred to where iron vessels have been lost for want of efficient water-tight subdivision of the hold. There is no difficulty in ascertaining the reason why ordinary iron ships are left open to the chance of such casualties. The rules which govern the practice of private ship-builders state the minimum number of bulkheads required in different classes of ships, and leave it to the ship-owner and ship-builder to decide whether a larger number of bulkheads shall be fitted. The "classing" of a ship, together with her rate of insurance by the underwriters, not being affected seriously, if at all, by the provision or non-provision of additional water-tight subdivisions, it is not surprising to find that the cheaper but less safe and strong arrangement is commonly preferred. The decision in favour of this course is, moreover, partly due to the consideration that the stowage of cargo in a merchant ship is much facilitated when the hold is free from obstructions or subdivisions. But, while this is true, the fact remains that, as regards safety, the common plan leaves an iron ship with an insufficient number of bulkheads.

Take, for example, a sailing ship built of iron in accordance with Lloyd's Rules. She need only have one bulkhead, fitted moderately near the bow, and known as a "collision" bulkhead, because it provides against injury to the bow in case of collision. No doubt the dangers from this cause are greater, and of more frequent occurrence, than those arising from penetration of the bottom abaft the bulkhead; but supposing a leak to occur in the after portion of the vessel, and to overpower the pumps, her loss would be almost certain. Taking the case of a screw-steamer, built in accordance with the rules, a not much more satisfactory arrangement is met with. Such a vessel would have, in addition to the collision bulkhead, two others enclosing the engine-space, and another placed near the stern. The latter is intended to provide against chance of injuries to the screw-propeller and shafting, such as have caused the loss of some ships; and the engine-room bulkheads are designed to keep that space as free from water as possible in case of injury to the other compartments. These compartments are, however, frequently so large that if one of them be injured and filled, the ship cannot be kept afloat.

More satisfactory arrangements are made in many vessels than are rendered compulsory by the rules, and such arrangements are obviously most requisite in passenger or emigrant ships, wherein large numbers of people are embarked, as well as in war-ships, where the chances of penetration under water by projectiles, by torpedoes, or by ramming, are great. Taking, for instance, one of the iron-built armoured ships of our navy, we find that in addition to a water-tight double bottom, she has eight or nine transverse water-tight bulkheads by which the hold-space is divided into compartments of comparatively moderate size. A slight injury would, as was before explained, only admit water into a small compartment of the double bottom, and not result in its entry into the hold; and this is most important, because it would practically prevent any loss of efficiency in the ship. But in case of a more serious injury occurring, and leading to the penetration of the inner as well as the outer skins, the water-tight bulkheads would confine the water to the damaged compartment, and the ship would remain afloat. Merchant ship-builders, as a rule, do not care to incur the expense of fitting double bottoms, or to lose the hold-space, which would not be occupied by cargo if there were an inner skin, and consequently they have to depend for safety entirely on the bulkheads, the arrangement of which should, therefore, be most carefully considered.

Two principal objects should be kept in view in making such an arrangement. The first, that no single compartment should be left so large as to sink the ship if it were filled; and the second, that in case any compartment were filled the water from it should not find its way into other compartments. The first is so obviously necessary to efficient subdivision that nothing need be said respecting it; but as the second is sometimes overlooked, a few words in illustration may not be out of place. Ships have been built with a sufficient number of bulkheads, but with these bulkheads ended too low down; so that if a compartment had been filled, the consequent increase in the draught of water of the ship would have sunk the tops of the bulkheads below the level of the water outside, and have allowed the water from the damaged compartment to flow over into the adjacent compartments; thus leading to the loss of the ship. In order to prevent this, the simplest plan is to carry the bulkheads up to such a height as will keep them above the water outside, even when the ship has been sunk deeper than her normal draught by the filling of a compartment. And if this is not convenient, the same end can be obtained by fitting a water-tight deck of iron along over the tops of the bulkheads. It should be added that it is usual to end the bulkheads at the height of one of the decks, so that the last-named plan can be readily carried out when required.

Before proceeding to describe the ordinary methods of constructing transverse bulkheads, we desire to refer briefly to the longitudinal bulkheads sometimes fitted in iron ships. These are generally subordinate to the transverse bulkheads, and are primarily constructed as partitions in the hold to shut off the spaces required for stowing particular parts of the equipment, such as coals, chain cables, powder, shell, etc. etc.; or to enclose water-tight passages, such as the shaft-passages of steam-ships, and the passages between the engine and boiler spaces when they are separated. Such longitudinal partitions may, by care on the part of the ship-builder, be turned into valuable longitudinal strengthenings, and also be made to form further water-tight subdivisions in the hold. Probably the best examples of such care may be found in the armoured ships of the Royal Navy, wherein every longitudinal partition of any importance

is, by a small expenditure of material in the form of stiffeners, turned into a girder; and every space of any size enclosed for special purposes is a subordinate water-tight compartment.

There have, however, been cases in which longitudinal bulkheads have been used primarily as strengthenings of a ship's structure, and raised from their subordinate position into prominence. The *Great Eastern* furnishes the most striking example of this arrangement. For about half the length of this vessel two strong bulkheads are built, reaching from the inner bottom to the cellular upper deck. These bulkheads form the side boundaries of the engine and boiler spaces, and do not interfere with the stowage of the hold. Being strongly built, and well stiffened, in addition to receiving valuable support from the intermediate decks, these bulkheads form most efficient girders; and not only lend their own strength to the structure, but also help the sides in connecting the cellular upper deck, forming the top flange of the girder, with the cellular double bottom, forming the lower flange. In fact, we find in this arrangement another illustration of that admirable combination of strength with simplicity which distinguishes every principal feature in the structure of this remarkable vessel.

There have been many proposals to construct similar longitudinal bulkheads in ordinary iron vessels; but the plan which answers so well in the *Great Eastern* is open to grave objections when applied in smaller ships, where it would interfere with the internal arrangements, particularly in steam-ships. For instance, it would not be easy, in a ship of moderate breadth, to secure sufficient space, between such longitudinal bulkheads, for the engines and boilers; and the stowage of cargo in the hold would be made difficult. To remove these objections, it has been proposed in such cases to have one instead of two bulkheads, placing it along the middle line of the keel; but this plan also has serious disadvantages. In short, as sufficient strength can in ordinary vessels be secured by other means, and the ship-builder left with greater freedom in making the interior arrangements, the use of these longitudinal bulkheads has not found favour, nor is it likely to do so unless the size of ships should be much increased.

Reverting to the consideration of the transverse bulkheads usually fitted in iron ships, we will endeavour to describe briefly the principal methods of constructing them, and afterwards notice some of the plans for securing them to the skin-plating.

The plating of bulkheads is usually worked in horizontal strakes, with the butts shifted either on the brick fashion (illustrated by Fig. 35, Vol. III., page 305), or on the diagonal plan (Fig. 36). In a few instances, however, the plates have been worked with their greatest lengths vertical. The edge-joints, as well as the butts, are generally lapped and single-riveted, and are caulked on the plan followed for outside plating (see Fig. 40, page 351). At the places where the laps and butts cross each other the corners of the butted plates have to be hammered out to a thin edge, so that they may form but one thickness under the edge-lap of the plates above and beneath them. Some builders have preferred to work bulkhead plating flush at the edges and butts; but this is a more expensive plan, and is not commonly used, although it has some advantages as regards strength.

Considering the thin plating of a bulkhead as in place, and subjected to the strains resulting from the motion of a ship at sea, it will be obvious that it would be liable to buckle in various directions, and might cease to be water-tight. In order to prevent such buckling, and to render the bulkhead efficient in assisting to maintain the transverse form of the ship, the plating must be stiffened. This is usually done by means of angle-irons riveted to the plating, and either placed vertically or else arranged in two sets, one being horizontal and the other vertical. The latter arrangement is to be preferred, as it makes the two sets of stiffening bars cross at right angles, and by uniting them to the plating, enables it to resist most efficiently changes of transverse form. When vertical stiffeners only are used, the attachments of the bulkhead to the decks and platforms constitute its sole horizontal stiffening, and this may not always be sufficient. When bulkheads enclose comparatively long spaces, such as engine-rooms, or boiler-rooms, or cargo-holds, where the transverse strength of the decks is considerably reduced by the large hatchways required, it is especially necessary to secure rigidity in the bulkheads; and this is sometimes done by increasing the thickness of the plating; but it is preferable to have recourse to stronger stiffeners. As an example of one of these special arrangements, we may refer to the bulkheads fitted amidships in the armoured ships of the navy. The plating is worked flush, at both the edges and butts, the latter being secured by plate-straps single-riveted. The horizontal joints of the plating are covered by T-iron stiffeners, stretching from side to side; and on the opposite surface of the plating vertical iron stiffeners are fitted at intervals of about four feet. Proposals have been made to use T-iron stiffeners vertically as well as horizontally, but we are not aware that the plan has been applied in practice.

Respecting the construction of the various subordinate longitudinal and transverse bulkheads in the hold, it is only necessary to say that the plating is usually arranged similar to that of the main transverse bulkheads, and stiffened by vertical bars of angle or T-iron.

The modes of securing transverse water-tight bulkheads to the skin-plating of iron ships next claim attention. One of the earliest and simplest connections is that where a single angle-iron is riveted to the edge of the bulkhead, and to the skin-plating; and another, still largely used, differs only in having two connecting angle-irons instead of one. Both these plans, however, are considered by many ship-builders to lead to too great a localisation of the connection between the skin and the bulkhead, and it is urged that means ought always to be provided for distributing the strength of the bulkheads over parts of the skin not immediately in wake of them. These objects are realised better by the connection illustrated in Fig. 57, which is much used in merchant ships. A single angle-iron forms, the main connection between the bulkhead and the skin; but additional strength of attachment is obtained by means of the horizontal "bracket-plates" (*a*, *b*), which also distribute the support of the bulkhead over two frame-spaces. These brackets are placed alternately on the fore and after sides of the bulkheads, and are near the middle of the strakes of the outside plating. They are very simply formed of plates and angle-irons, and are of considerable service in ordinary iron ships with transverse framing.

This sketch also enables us to refer to the practice of fitting broad liners to the outer strakes of the skin-plating in wake of transverse water-tight bulkheads. In the plan in Fig. 57, it will be seen that the liner stretches from the frame before the bulkhead to that abaft it, and this is the common practice in merchant ships; narrower liners are sometimes used, and may be made to answer the same purpose. These broad liners are fitted because the rivets in the angle-iron connecting the bulkhead with the skin have to be spaced very closely in order to secure water-tightness, their pitch not exceeding five or six diameters. Consequently, the plating is much more weakened in wake of the bulkheads than it is in wake of the transverse frames where the pitch of the rivets is greater; and in order to do away with this inequality of strength, the liners in wake of the bulkhead are broadened so that they may act as *butt-straps* to the specially weakened lines on the plates. The plan is simple, but thoroughly efficient, and its use prevents a recurrence of disasters similar to those which occurred with some of the earlier iron vessels, where, in their anxiety to make the bulkheads water-tight, the builders so weakened the skin-plating that the vessels broke down the sides when severely strained at sea.

In addition to these common methods of securing water-tight bulkheads reference might be made to other plans; but as most of these have rarely, if ever, been employed, we must pass them by unnoticed. Respecting the bulkhead connections in ships built on Mr. Scott Russell's longitudinal system, it will suffice to say that when there is no double bottom the edge of the bulkhead is secured to a belt of plating worked inside the longitudinal frames for the purpose; and when there is a double bottom, the edge of the bulkhead is directly connected with the inner skin. The latter mode of attachment is also employed in the armoured ships of the navy built with double bottoms. In both cases it will be remarked that the longitudinal frames act as most efficient distributors of the strength of the bulkheads over the intervening spaces, and render the use of bracket-plates, such as *a*, *b*, in Fig. 57, quite unnecessary. Mr. Russell relies, in fact, principally on the bulkheads for supplying transverse strength to his ships, and experience shows that under ordinary circumstances his expectations are realised, and the

forms of the ships are maintained. He uses also "partial bulkheads," as before described, in order to further strengthen the structure; but does not make his transverse framing so prominent as that of the iron-clads built on the bracket-plate system. The latter system, however, has been shown to possess considerable advantages as compared with Mr. Russell's system, especially as regards the efficient support of the bottom plating; and while in the iron-clads the bulkheads are made to supply the greater portion of the transverse strength, they are not left so unaided as in ships built on the longitudinal system.

When fitted in wood ships, transverse iron bulkheads are secured to the inside of the timbers and ceiling by single or double angle-irons riveted to the bulkheads, and bolted through the ship's side; but in composite ships similar bulkheads would simply be riveted to one of the frame angle-irons. In neither case, however, can the water-tightness of the bulkheads be ensured so thoroughly as is possible in an iron ship.

Longitudinal strengthenings, such as keelsons, hold-stringers, etc., ought not to be stopped short at bulkheads, but either continued through them, or otherwise arranged so as to form continuous ties. Supposing them to be run through the bulkheads, which is the simpler plan, it then becomes necessary to make them water-tight. This can be done readily by fitting forged angle-irons closely around the keelson or stringer, and against the bulkhead. After riveting these angle-irons it is possible to caulk all the joints, either on the lap or flush system.

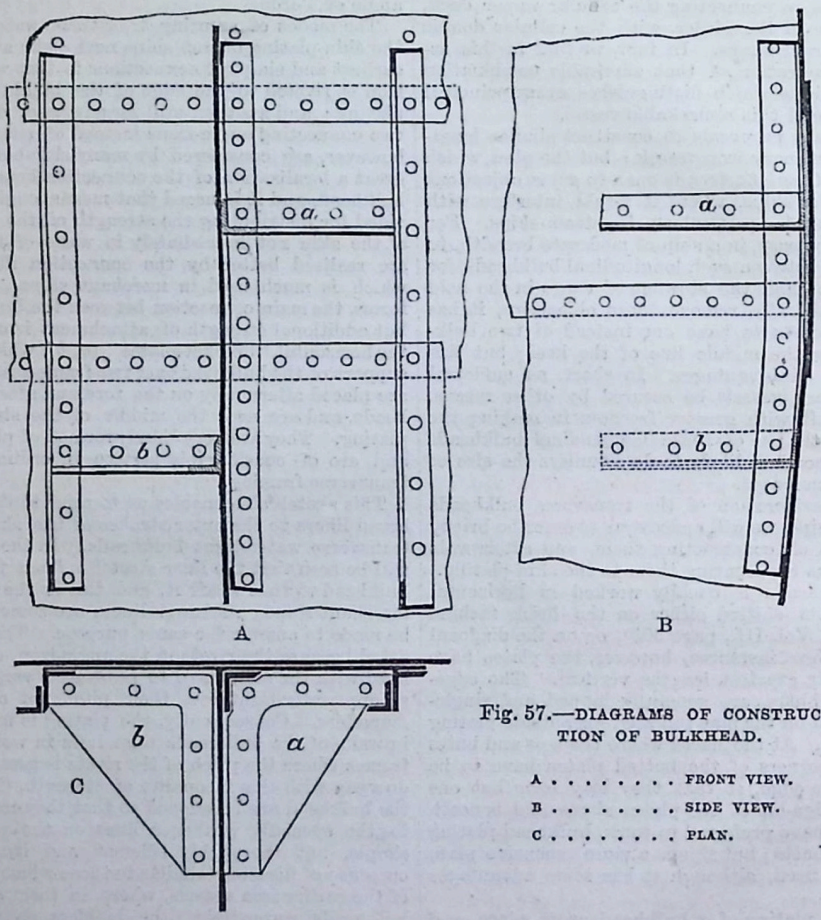


Fig. 57.—DIAGRAMS OF CONSTRUCTION OF BULKHEAD.

A . . . . . FRONT VIEW.
B . . . . . SIDE VIEW.
C . . . . . PLAN.

Care must also be taken to test the water-tightness of the bulkheads after the work is completed, if efficiency is to be ensured. One mode of testing is to fill the compartments with water, in order to detect any leaks that may exist; but this involves much labour and expense when the compartments are large, and a more common plan is to pump water upon the bulkhead (by means of a fire-engine and hose) with considerable velocity. In testing the compartments of the double bottom in the iron-clad ships of the navy, it is usual not only to fill the compartments, but also to put the water in them into communication with a stand-pipe, also filled with water, and leading up to the height of the loadwater-line. By this arrangement it is ensured that there shall be no leak under the maximum pressure to which the boundaries of their respective compartments are subjected when the ship is afloat.

For the purpose of facilitating communication between the different parts of the hold, openings are frequently made in the water-tight bulkheads, and water-tight doors are required. These doors are usually formed of cast or wrought iron plates, and are made to slide either vertically or horizontally in grooved framework fixed on the bulkhead plating. The edges of the door are commonly wedge-shaped, and so also are those portions of the grooves in which the door rests when it is shut; so that a close fit of the bearing surfaces of the door and framework is ensured, and water-tightness is secured. In order to give the necessary sliding motion to these doors, vertical shafts or rods are generally fitted, being made to extend up to one of the decks, where they can be turned by means of a spanner or other device worked by hand. If the doors slide horizontally, their motion is generally caused by pinions on the shafts gearing with racks fixed on the door. If the doors move vertically, there are usually screw-threads cut on the lower ends of the shafts, and these work in nuts secured to the doors. All these arrangements, however, are open to endless modifications; but what is really important in all of them is to give the crew of a ship the power of closing the water-tight doors from the deck above, even after the rush of water into a damaged compartment has begun; and to enable them to ascertain, without actually going down into the compartment, whether the doors are closed or not. Similar precautions are necessary in fitting "sluice-valves" to water-tight bulkheads. These valves are usually opened or shut by means of rods leading up to one of the decks, and are intended to allow the bilge-water to flow from one compartment into another when the pumps are at work.

In the iron-clads of our navy the bulkheads extend up to the main deck, and it is very important that ready means of passage fore and aft should be provided on the lower deck. For this purpose light hinged doors, formed of plate-iron, stiffened on the edges, have been fitted to the bulkheads. When closed, these doors fit closely into a rabbeted frame fixed to the bulkhead plating, and are pressed tightly (by means of wedged catches) against a "beading" of india-rubber fitted in the rabbet for the purpose of making the joint water-tight. This plan is simpler and much less costly than that followed for the water-tight doors in the hold, and it answers perfectly in the places where it is used, because, being at such a small depth below water, there is every probability, in case of an in-rush of water, of sufficient time being obtained to close these doors and secure them by hand before the water rose high in the compartment. In the hold, as we have already remarked, the case would probably be different, and the doors must therefore be so fitted as to be closed by some simple train of mechanism worked from above; besides which they must be made capable of sustaining a considerable pressure of water without leaking. It need hardly be added that the water-tightness of all such doors, wherever placed, should be carefully tested; and this is usually done when the bulkheads themselves are tried.

MINING AND QUARRYING.—XXVIII.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

RED LEAD OR MINIUM—CHLORIDE OF LEAD—WHITE LEAD OR CERUSE—DUTCH PROCESS—THENARD'S PROCESS—LEAD-POISONING.

In addition to the oxides of lead described in the last article, there is another of very extensive use in the arts, and the manufacture of which forms a special trade. It is commonly known as red lead or minium. The very finest metal is used for the purpose, especially if the red lead is intended for sale to the flint-glass makers, as the presence of other metals will prevent the glass from being so clear and lustrous as it would otherwise be.

The first step in the manufacture is to convert the lead into the familiar protoxide, which is more usually called "dross" by the workmen than litharge or massicot. The drossing-oven is on the reverberatory principle, but it is generally made with a fire on both sides of the hearth, as shown in the diagram (Fig. 1), and without a chimney, the waste gases escaping from the top of the working-door. The heat required does not exceed dull redness, and some ovens are even made without fire-bars, there being sufficient draught from the charging-doors to keep lumps of free burning coal alight. The flames from the fires pass over the fire-bridges, A A, and circulate over the hearth B, which is about flat, and is so shaped that the whole area of it can be rabbled from the working-door, C. Just inside the latter a dam is made to prevent the lead when it melts from running out, and then the charge, consisting usually of something over a ton of lead, is introduced. If the minium is not intended for the glass manufacturers, about 1 cwt. of slag lead is added, the antimony which the latter contains having the effect of greatly expediting the oxidation of the whole mass. As soon as the lead has melted, rabbling is commenced and kept up vigorously, so as to expose the lead as much as possible to the action of the air; and as the oxide forms it is pushed up in a heap at the back of the oven. This process is continued for several hours, and then the dam is removed, and whatever lead remains unconverted is run out and put aside to be added to the next charge. The "dross" is then raked out from the back of the furnace and left to cool. It is next taken to the grinding-mill, where it is ground under millstones to an impalpable powder, or rather made into a fine paste as it is ground with water. From the mill it flows into the puddler, where it is agitated in water, and the finer powder is afterwards separated from the coarser in settling tanks. From these it is taken (after being dried) to the colouring-oven, which, in some works, is the same as the drossing-oven above described, and it remains there exposed to a moderate heat, varying from 550° to 600° Fahrenheit for about forty-eight hours. During this time it is frequently rabbled, and by the period named it will have acquired the full red tint characteristic of red lead. It is finally re-ground and sifted, when it is ready to be packed in casks for the market. The product should show an actual gain in weight of 7 or 8 per cent., due to the absorption of oxygen.

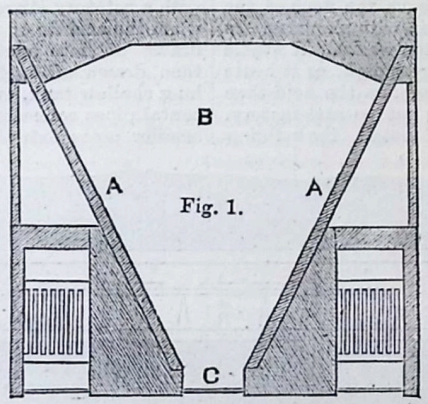


Fig. 1.

Minium is used for very similar purposes to litharge; but as a pigment it furnishes a much superior colour: ground in oil it forms a paint which possesses in a high degree the faculty of drying rapidly in the air. In the glass and pottery manufacture one of its chief values consists in the readiness with which it combines with silica and alumina, forming with them a vitreous compound or glaze. The acetate of lead has been already described in the series on "Chemistry applied to the Arts," No. XV.

The chloride of lead is a salt which has only recently been manufactured on a large scale. It is used by painters, and has the advantage over the carbonate of lead, which is generally used, in not being blackened by the sulphide of hydrogen, which so often causes the discolouration of white paint, especially in large towns.

The carbonate, generally called white lead, flake white, or ceruse, is, however, the almost universal foundation for all lead paints, and is therefore an article of very extensive manufacture both in this country and on the Continent. Some of the German makers used to be very celebrated for the superior quality they produced; but now our own manufacturers leave nothing to be desired in this respect.

The usual plan, commonly called the Dutch, consists in exposing lead for a prolonged period to the gentle action of the vapour of acetic acid and carbonic acid gas. The effect of this is to produce an acetate of lead, which is converted in its turn into a carbonate. The mode by which this chemical change is brought about is somewhat peculiar. The factory consists of a large building having the sides, one of which is represented by A (Fig. 2), divided by brickwork partitions, B, B, into a series of recesses or chambers, which are partially open towards the centre of the premises. The dimensions of these chambers are about fifteen feet each way for the area, and the height from the floor to the roof about twenty feet. As a matter of convenience, the floor of the recesses is generally sunk some feet below the rest of the building. These are the receptacles for the stacks, which are built up in the following manner:—The sides are lined all round with spent tan for about sixteen inches, and a layer to about a similar depth is spread over the bottom; upon this a quantity of earthenware pots, containing a little acetic acid or vinegar, are set in regular rows as close as they can stand, and on the top of the pots slabs of lead are laid; a floor is then made of planks, and upon this another layer of tan, pots, and lead; and so on until the stack is complete. A stack will thus contain a series of eight to ten beds, one above another.

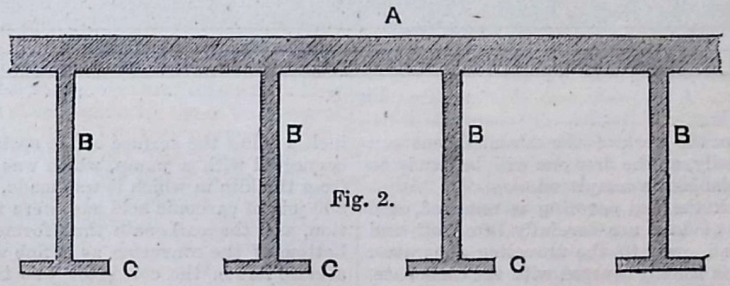


Fig. 2.

In Fig. 3, B will represent one of the partitions, and D the floor of the recess; E E, etc., the tan; F F, the pots; and G, the lead slabs. Of these, however, a few more details must be given. In some manufactories stable dung is used instead of tan; the functions performed by either the one or the other are the same—that of creating a considerable warmth which assists the evaporation of the acetic acid, and of evolving the carbonic acid which is necessary to convert the acetate into the carbonate. The use of dung is, however, objectionable, because it also evolves some sulphuretted hydrogen, which is liable to destroy the perfect whiteness of the product. The pots, it will be observed, are of two sizes and shapes: the larger ones taper very much to the bottom, while the smaller do so very slightly, if at all. In some works they are just the shape of common jam pots. The larger pots are about eight inches high, and made with a ledge running round the interior; the part below the ledge is filled with weak acetic acid, and a spiral coil of lead is placed in the upper part, and rests upon the ledge, so as not to touch the acid. In each of the smaller pots a little acid only is poured; except here and there, where one or two of them are nearly filled with common vinegar. Upon the top of the smaller pots are laid the slabs of lead. The metal for this purpose is melted in an iron pot at a low temperature, from

which it is ladled out and poured upon an iron slab grooved with longitudinal and transverse gutters an inch apart, into which the lead runs: it thus forms a perforated slab resembling a grating or trellis-work. For the coils put into the larger pots, the lead is cast into long narrow strips, which are afterwards rolled up into coils. The slabs of lead are made in the form selected in order to allow of a free circulation of air around them, and also to admit of their expansion, as during the process they swell up to about three times the size of the original metal; additional space for this purpose is allowed between them and the planking, H H, which rests upon the rim of the larger pots and supports the next bed. The uppermost bed of all is covered with the tan or dung to the depth of about two feet; and as the beds are built up above the floor of the workshop, the open side, C (Fig. 2), is filled in with planking. In this condition the stack is left for six to ten weeks. If stable litter is used, the former time will be long enough, as it heats more than tan—sometimes, indeed, too much, as the acid then evaporates too rapidly, and the produce is not so satisfactory. Each stack will contain ten or twelve tons of metal. By building up each stack in succession the work of the establishment can be kept going uninterruptedly, as the first one will be ready to be dismantled as soon as the last is completed.

In taking down the stack the top covering is removed, and then the slabs and coils of lead are carefully lifted off and put into boxes to be carried away to the unscaling apparatus. The lead, partly corroded, is thickly covered with the carbonate, a flaky white substance, consisting of particles so finely divided that unless handled with care some of it is apt to get into the air, when it would exercise a very injurious effect upon the health of the workmen. They even wear leather gloves in some factories, so as to avoid touching it with their hands. The removal of the carbonate from the metallic core is done by passing the pieces under grooved rollers, and agitating them under water, and the metal is returned to the melting-house. The carbonate, while still wet, is passed under a series of mill-stones, from which it issues in a pasty state, and is conducted into the settling vats. When the water has separated and become perfectly clear it is drawn off, and the carbonate is put into flat dishes and ranged on shelves in the drying-room. This is heated by a close iron stove in the centre, which is supplied with fuel from the outside, and here the carbonate of lead is thoroughly dried in the course of a few days. It then only remains to knead it up with oil, and pack it in casks.

It is seldom, however, that the white lead made for painters' use is pure. There are mixtures well recognised in the trade, which bear specific names. Venetian white consists of equal parts of carbonate of lead and sulphate of baryta; Hamburg white, one-third of the former and two-thirds of the latter; and Dutch white, one-fourth and three-fourths respectively.

There are other modes of preparing white lead, most of which are modifications of the principle first carried out successfully at Clichy in France, whence the article produced by this process is often called "Clichy white." Thenard's system, which is the basis of all these, consists in preparing a solution of basic acetate of lead, and then passing carbonic acid gas through it, producing the carbonate of lead and a neutral acetate. The apparatus used at Clichy consisted of a large vat furnished with a rotatory stirrer for dissolving litharge in acetic acid, and when the acetate of lead had attained a proper strength it was drawn off into another vat to settle. The clear liquor was then drawn off again from this into the converting vessel, a long shallow tank, over which depended a series of twenty horizontal pipes connected with a main, and from each of these forty smaller pipes extended perpendicularly to a depth of thirteen inches below the surface of the acetate of lead. The main was connected with a pump, which was supplied with carbonic acid from the kiln in which it was made. When at work, therefore, 800 jets of carbonic acid gas were injected into the lead solution, and the carbonate thus formed was thrown down to the bottom of the converter as a fine white powder. The neutral acetate left in the converter was then drawn off into the first vat to dissolve up more litharge, and the carbonate of lead transferred to a vat to be washed, after which it is ready for drying and packing.

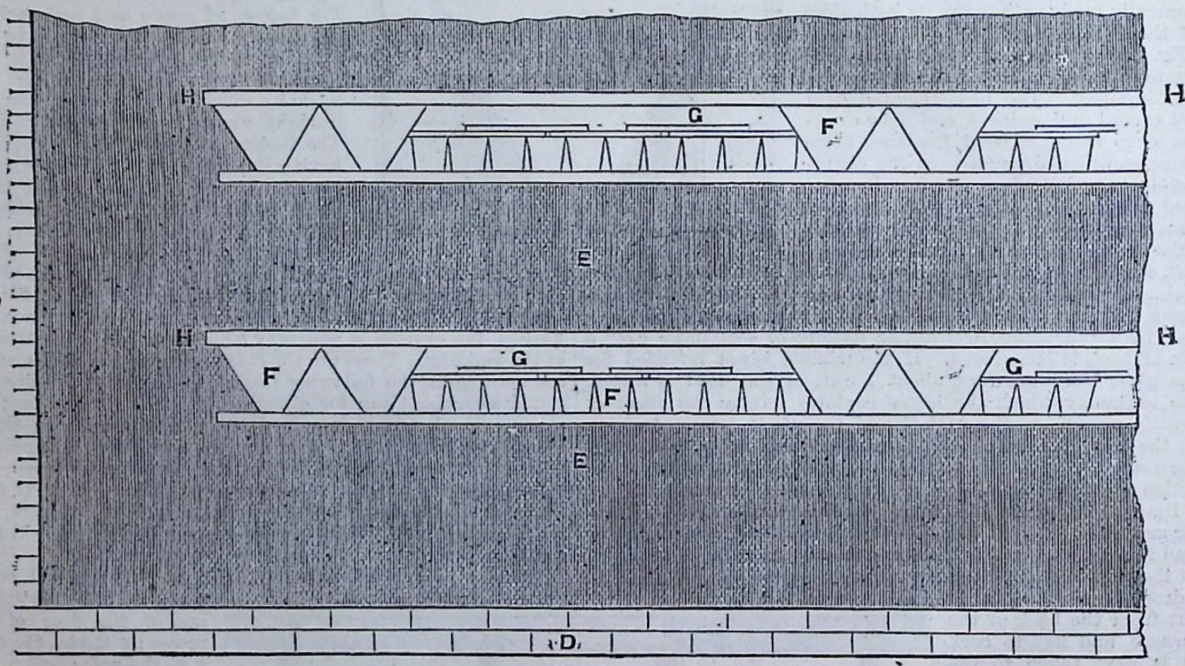


Fig. 3.

In the course of this and the preceding papers on lead the deleterious character of its salts has been referred to several times, and painters' or lead colic is unfortunately but too well known. Indeed, with the exception of the sulphides, sulphates, and phosphates, which are very insoluble, the whole series of lead salts may be considered more or less poisonous. Except in certain manufactures, and especially where the carbonate is dealt with in the dry state, such precautions are generally taken as to prevent active lead-poisoning; but the cases are not rare where the slow action is continued through long periods of time, producing at length distressing symptoms. This often arises from the water used for drinking or cooking being conveyed through leaden pipes, and held in cisterns lined with lead. Spring water may generally be brought in contact with lead without any bad effect, as the mineral matters contained in it

will most probably form an insoluble compound with the oxide of lead; but rain-water, or any surface-water which contains nitrogen, or any organic matter which will evolve nitrogen, exercises a most pernicious effect, as this element acts immediately on the lead. Fortunately, the presence of even the smallest trace of lead in water may easily be detected. It may be done by putting in the water two or three drops of acetic acid, and then adding about one-twentieth of its bulk of an aqueous solution of sulphuretted hydrogen. On looking down through a tube containing a column of water so prepared, 10 inches in length, upon a white surface, and comparing it with a similar tube containing the water without addition, a brown discolouration, more or less intense, will be seen in the one containing the sulphuretted hydrogen, if lead be present. By taking a standard solution of lead of known strength, the quantity of lead in water may be ascertained very correctly by comparing the depth of colour. The deleterious action of nitrogenous substances in water held in leaden cisterns may be prevented by the insertion of some coils of iron wire, for which the nitric acid has great affinity; but the safest plan of all is to substitute pipes and tanks of some other material.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XIII.—LECTURES AND DEMONSTRATIONS.

Lectures and Demonstrations.—It would at first sight appear obvious that lectures should be given on the collections of the several departments of a national museum, to ensure the public deriving the full advantage of its scientific wealth; but there is great diversity of opinion on the subject, and many eminent men hold a different opinion. Thus Professor Huxley considered that a museum may be regarded as a consulting library of objects, and that lectures on the objects are not more necessary than on the books in a public library.* Others considered that teaching should be accessory only, and chiefly for demonstrating the character of any newly-acquired remarkable specimens. At the Jardin des Plantes, the lectures have not been appreciated as fully as might have been expected, and their ablest lecturers have found that after their first and second lecture, their auditors have diminished to six or seven constant attendants, *but then those six or seven afterwards became men of repute!* In our own country we have met with similar experience. Thus, at Oxford, Professor John Phillips gives an annual free course on some subject of geological interest: a few years since it came to my knowledge that he had prepared a most interesting series of demonstrations on fossil echinodermata, but after the first lecture he had only *one* regular attendant—a well-known palæontologist; but Professor Phillips went manfully through the entire course to the satisfaction of himself and his solitary auditor, as he dropped university formalities, and both went into the subject *con amore, tête-à-tête.*

Cuvier and Geoffroy complained of the injury often inflicted on choice specimens by their removal to the lecture-theatre; and further, that the utilisation of the Museum specimens for lecture purposes, entailed loss of the curator's time in having to derange and re-arrange the cases. Such objections may be obviated by giving demonstrations in the galleries in place of lectures in a theatre, which would not entail the removal of the specimens; but Dr. J. E. Gray is of opinion, from what he has seen at the British Museum and College of Surgeons, that from the crowding of the auditors on the demonstrator, and the manner in which the specimens are obstructed from the view of a great number of persons, such a system does not give promise of a successful method of imparting instruction, but that catalogues are the most convenient guides for the general public. From the evidence we have before us in the "Report of Committee on Public Institutions" as to the manner in which the public lectures at the School of Mines have been appreciated by the working and middle† classes, and the wide-spread increasing taste for scientific knowledge, especially in the department of Natural History, the success of the Quekett Club and similar microscopic and natural history associations in London and the provinces to wit, together with the commencement in earnest of science-teaching in our public schools, affords justification for believing Professor Owen's inclusion of a lecture-theatre in his plan for a National Museum of Natural History, an act of sound policy, with the view of extending sound information among the people on "the extent and variety of the Creative power." He considers that, during the year, at least nine courses on as many branches of Natural History should be given in connection with the Museum, popular lectures in the theatre connected with the Elementary, British, and Geographical* collections, and advanced lectures three times a week on the special departments by their keepers to a limited number of persons who have attained a certain standard of scientific knowledge, but without establishing any restriction as to class. Twelve to twenty lectures to be given by each keeper. Probably it would be better if the advanced lectures were given in the galleries to which each subject pertained in the form of demonstrations, as then the specimens, except in exceptional instances, need not be removed from their cases, thus meeting the objections raised on the score of possible damage to the systematic collection, which would include the rarer objects of the Museum. Such demonstrations should be given from four to five o'clock, after the closing of the galleries to the general public. The objectionable crowding on the demonstrator could readily be provided against in a limited class, by portable barriers that could be removed from one spot to another, together with a diagram screen and blackboard. Such demonstrations by those whose duty it would be to be "posted up" in the latest knowledge pertaining to their special department, would be most advantageous and acceptable to working naturalists, and would generally tend to the extension of sound research among British students and naturalists.

The subject of lectures on our national collections raised the question as to whether it should become one of the necessary duties of a keeper or assistant keeper of a department to give a course of lectures. It was argued that the qualities for a good curator and a good lecturer are not always combined in the same person. The qualities calculated to attract an audience are by no means the qualities necessary to constitute a good curator. Patient research, constant attention to detail, care in the compilation of catalogues, taste and skill in arrangement, capacity for administration, are essential for the one; an easy delivery, and power of popular illustration, are chiefly required in the other. A good lecturer might not be a sound naturalist, but his acquired popularity might be brought to bear, and pressure put upon the appointing powers, to secure his election (though not the best man among the candidates) as curator of a department. Such an objection would naturally be raised by those curators who had never taken any position as lecturers; but we have among us men who have attained eminence in both capacities; and on the Continent, especially at the German universities, the professors are, as a rule, the curators of the collections in the University Museums, that illustrate their own subjects. Were the duties of curator and lecturer made distinct, it would deprive some of our most distinguished teachers of the control of the specimens that illustrated their lectures, and moreover might lead to want of harmony between the doctrines as enunciated in the lecture-room, and the arrangement of the collections in the Museum. Moreover, curators would naturally object to be made responsible for the safe keeping of lecturers who were not on the Museum staff, if a separate staff of curators and lecturers were established; but if the demonstrating system were determined on for the systematic series, it would remove many of the difficulties that have been raised to the union of the two offices, as elegance of language, easy flow of words, and facile illustration, are not so essential for the terse and practical descriptions of the demonstrator. The keepers of a National Museum are really the only persons naturalists, etc., could look to for *information in detail* on all the great divisions of Nature, or in other departments of knowledge. Thus, at the present moment, the most extensive Government course on *general*

* Report on British Museum Committee.

† Evening lectures at a fee of five shillings a course have been provided for the middle classes, which have always been well attended.

* As the geographical groups would be unsuited for removal to the lecture-theatre, counterpart photographs could be shown on a large scale by means of the demonstrating lantern, and so the public could be familiarised with the detailed history of the groups themselves.

Natural History comprises forty lectures on Mineralogy, *none on Botany*, eighty on Zoology (embracing Comparative Anatomy, supplemented by demonstrations on Palæontology), and thirty-six on Physical and Stratagraphical Geology, which only admits of typical illustration.

TECHNICAL DRAWING.—LXXIX.

DRAWING FOR CABINET-MAKERS.

FIG. 613.—In the present study the bookcase is turned so that the front is at right angles to the plane of the picture, the narrow side (or depth) being parallel with it.

Draw the rectangle A D F′ F, representing the narrow side, and having drawn the horizontal line at the same height as in the previous lesson, set off the point of sight at eight feet (in this case) on the left of the perpendicular A, and the point of distance at eleven feet on the right of the point of sight, both of these points being, as in the last lesson, omitted from the illustration.

From A and D draw lines to the point of sight. From A set off A B, equal to the width of the front of the case, as shown in the last study, and from B draw a line to the point of distance, cutting the line drawn from A to the point of sight in B′.

At B′ erect a perpendicular, meeting the line drawn from D to the point of sight in C, thus completing the representation of the object rendered as a block.

From A set off A *a*, and from B set off B *b*, the real thickness of the wood, and from *a* and *b* draw lines to the point of distance, cutting A B′ in *a*′ and *b*′; at these points draw perpendiculars.

Now on the perpendicular A set off A *i*, equal to A *a*, and set off the same length from D, viz., D *d*. From *i* and *d* draw lines to the point of sight, and thus the apparent thickness of the wood forming the carcase will be represented.

We have now to show the interior of the case; and in order to do this, it becomes necessary to render the narrow side A D F′ F transparent. Therefore draw (in dotted lines) the ends of the top and bottom, viz., *i k* and *d l*, and also the perpendicular *k l*, showing the thickness of the back of the case.

Now from *k* and *l* draw lines to the point of sight, and from *m* and *n* draw horizontals, cutting these in *p o*. Then the perpendicular *p o* will complete this portion of the subject.

We now proceed with the shelves. Mark the thickness of these at their proper places on A D, and draw lines from these points to the point of sight, observing, of course, that these lines are not to be drawn across the thickness of the framing, but only between the lines forming the inner edges of the walls.

Now from the points marking the positions of the shelves, as *q*, *r*, draw horizontal lines representing the ends of the shelves as they would appear if brought quite up to the plane A D F′ F. These ends, however, must not be carried as far as the line F F′, but only up to *k l*, which represents the inner line of the boards forming the back of the case, the shelves thus terminating as shown at *s t*.

From *s*, *t*, *u*, *v*, *w*, *x*, *y*, draw lines to the point of sight, cutting the perpendicular *o p*; then horizontal lines drawn from the distant ends of the shelves, as at *z*, meeting the others on the line *p o*, as at *z*′, will complete the view of the case of shelves when placed at right angles to the plane of the picture, and eight feet to the right of the spectator.

The subject of the next lesson (Fig. 614) is another view of the sideboard forming Fig. 51 in lessons on "Practical Perspective," page 149, Vol. II. of THE TECHNICAL EDUCATOR. In the present case the sideboard is turned, so that the end is parallel with the plane of the picture, and thus the horizontal lines of the front, being at right angles to the end, converge to the point of sight.

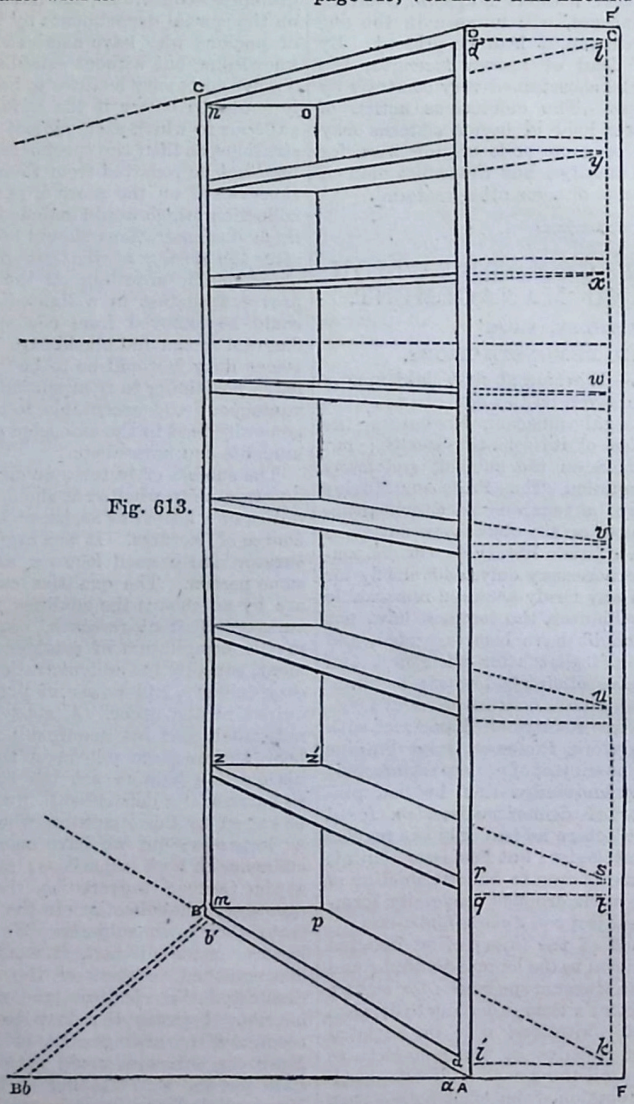


Fig. 613.

In commencing this figure, draw the side of the plinth which is on the picture line, *a b c d*, and from *a*, *c*, and *d* draw lines to the point of sight—viz., *a e*, *c f*, and *d g*.

Now on the picture line set off from *a* the length *a h*, representing the real width of the front of the plinth (equal to *a b*, the base of the plinth being square). From *h* set off *h i*, the width of the recess between the pedestals of the sideboard; and from *i* set off *i j* (*j* not shown in the figure), representing the width of the other plinth. These measurements may be taken from the front view (Fig. 51, Vol. II., p. 149). From *h*, *i*, *j* draw lines to the point of distance, cutting *a e* in *h*′, *i*′, and *j*′; and at these points erect the perpendiculars *h*′ *k*, *i*′ *l*, and *j*′ *m*. From *k*, *l*, and *m* draw horizontals to meet *d g*, and complete the distant plinth by the horizontal drawn from *i*′.

Draw diagonals in the upper surfaces of the plinths.

From *d* on *d c* set off *d* B*, equal to the distance at which the pedestal cupboards stand back from the front of the plinths, and from B draw a line to the point of distance. From the point at which the line drawn from B cuts *d g* draw a horizontal line, cutting the diagonal drawn from *c* in *n*. From *n* draw a line to the point of sight, which will cut the diagonal drawn from *k* in *o*, and being produced will give similar points in the distant plinth. At these points erect perpendiculars—of indefinite height, for the present.

Now draw the slab of the sideboard at the height corresponding with that in the previous figure, its angles being formed by perpendiculars raised from those of the plinths, with which, as already stated, they correspond.

Draw the rectangle C G *q p*, representing the end of the back, and produce it to J, J′ indicating the section of the back at its highest point.

From C and G draw lines to the point of sight, and at D draw the perpendicular D H.

* The points indicated by small capital letters, correspond with those similarly marked in Fig. 51 (Vol. II., page 149).

Fig. 614.

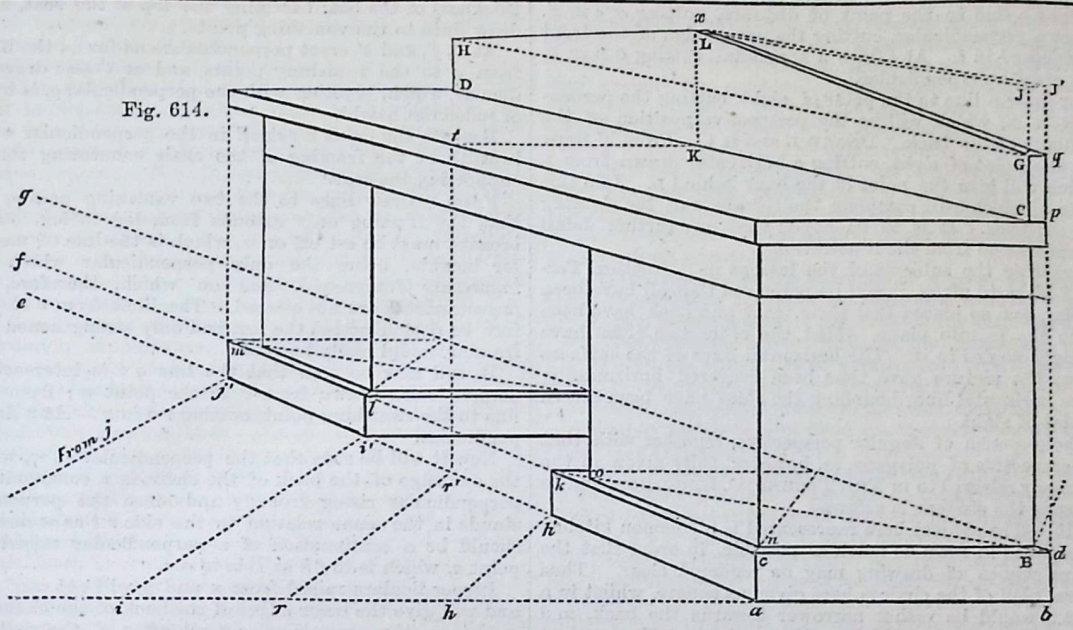


Fig. 615.

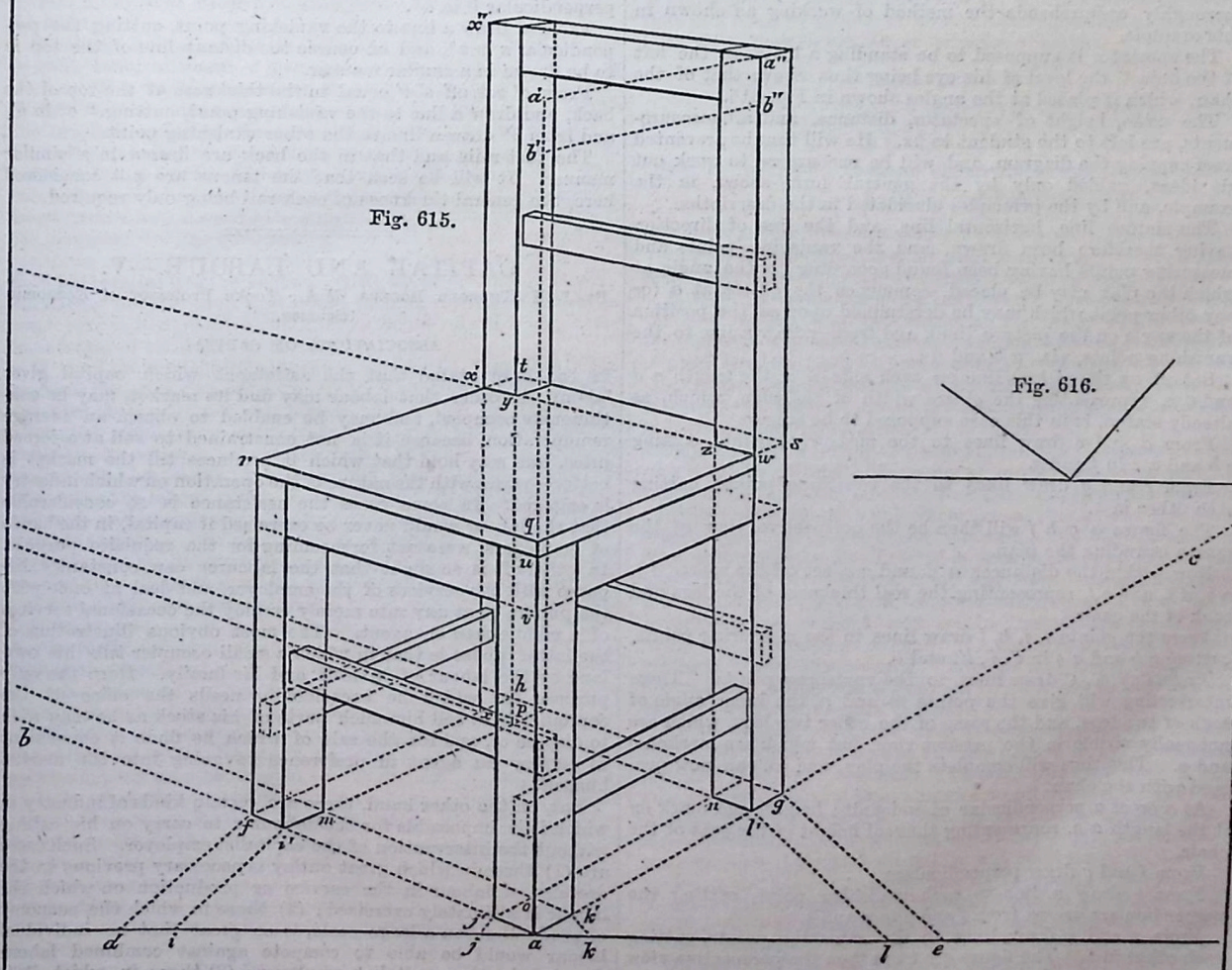


Fig. 616.

Half-way between h and i on the picture line mark r, and from r draw a line to the point of distance, cutting a c in r'. At r' erect a perpendicular, cutting the upper edge of the front of the sideboard in t. At t draw a horizontal, cutting C D in K, and at K erect a perpendicular.

From J draw a line to the point of sight, cutting the perpendicular K in L, which will be the perspective position of the highest point of the back. Draw G L and H L. From J′ draw a line to the point of sight, cutting a horizontal drawn from L in x, which will give the point of the back behind L. Join this point x to q, which will complete the thickness of the slanting edge of the back. It is to be hoped that any further detail will be understood from the illustration.

On reviewing the subjects of the lessons in "Practical Perspective" hitherto given, it will be perceived that all have been rectangular, and so placed that their front and back have been parallel to the picture plane, whilst the other two sides have been at right angles to it. The horizontal lines of the surfaces parallel to the picture have thus been rendered horizontally, whilst the horizontal lines bounding the sides have been drawn to the point of sight.

The whole system of angular perspective, together with that of the perspective of polygons, is, however, fully given in the course already referred to in THE TECHNICAL EDUCATOR, and to these lessons the student is referred.

Fig. 615.—The subject here represented is a common kitchen chair, simplified in form as much as possible, in order that the leading principles of drawing may be rendered clear. Thus the general plan of the chair is here given as square, whilst in a real chair it would be rather narrower towards the back, and the top rail is rendered as thick as the uprights. The student will soon, however, be able to vary these proportions when he thoroughly comprehends the method of working as shown in this example.

The spectator is supposed to be standing a little on the left of the object, the level of his eye being thus above that of the chair, which is placed at the angles shown in Fig. 616.

The scale, height of spectator, distance, and all measurements, are left to the student to fix. He will thus be prevented from copying the diagram, and will be encouraged to work out his ideas, guided only by the general form shown in the example, and by the principles elucidated in the description.

The picture line, horizontal line, and the line of direction having therefore been drawn, and the vanishing points and measuring points having been found according to the angle at which the plan may be placed, commence the object at a (or any other point which may be determined upon as the position of the angle on the picture line), and from a draw a line to the vanishing points, viz., a b and a c.

Set off on the picture line on each side of a, the length a d and a e, representing the entire width of the plan, which, as already stated, is in this case supposed to be square.

From d and e draw lines to the *measuring* points, cutting a b and a c in f and g.

From f and g draw lines to the *vanishing* points, cutting each other in h.

The figure a g h f will then be the perspective view of the square bounding the plan.

Now within the distances a d and a e, set off the spaces a j, a k, d i, and e l, representing the real thickness of the legs and back of the chair.

From the points i, j, k, l draw lines to the measuring points, cutting a b and a c in i', j', k', and l'.

From i', j', k', l' draw lines to the vanishing points. These intersecting will give the points m and n, the inner angle of each of two legs, and the same of the other two legs, which are not really visible in the present view, but which are marked o and p. This then will complete the plan, and we can now proceed with the chair.

At a erect a perpendicular of indefinite height, and mark on it the length a q, representing the real height of the seat of the chair.

From f and g draw perpendiculars.

From q draw a line to each vanishing point, cutting the perpendiculars drawn from f and g in r and s.

From r and s draw lines to the vanishing points, cutting each other in t. The figure q r t s is then the perspective view of the seat of the chair.

Beneath the point q set off on the perpendicular q u the thickness of the board forming the top of the seat, and from u draw lines to the vanishing points.

At i', j', and k' erect perpendiculars as far as the lines drawn from u to the vanishing points, and at l' also draw a perpendicular, which, together with the perpendicular g, is to be drawn of indefinite height.

Beneath the point u set off in the perpendicular u v the real breadth of the framing of the chair connecting the legs and supporting the seat.

From v draw lines to the two vanishing points, observing that the framing only extends from leg to leg, but the real breadth must be set off on a, which is the line of measurement for heights, being the only perpendicular which is in the immediate foreground, and on which, therefore, the true measurements are not altered. The lines from v should therefore be dotted across the leg, and only strengthened where the framing would really be seen.

It will now be seen that the line q s is intersected by the perpendicular drawn from l' in the point w; from w draw a line to the vanishing point, cutting r t in x'. At x draw a perpendicular.

Now it will be seen that the perpendicular at w, which gives the one edge of the back of the chair, is a continuation of the perpendicular rising from l'; and since the perpendicular x' stands in the same relation to the side r t as w does to q s, it should be a continuation of a perpendicular raised upon the point x, which is to f h as l' is to a g.

Perpendiculars raised from n and p will cut w x' in y and z, and will give the inner edges of the back of the chair.

Now on the perpendicular a set off a a', the real height of the back, and draw a line to the vanishing point, cutting the perpendicular l' in a''.

From a'' draw a line to the vanishing point, cutting the perpendicular x in x'', and of course the distant line of the top is to be drawn in a similar manner.

From a' set off a' b' equal to the thickness of the top of the back, and draw a line to the vanishing point, cutting l' a'' in b'', and from b'' draw a line to the other vanishing point.

The foot-rails and that in the back are drawn in a similar manner. It will be seen that the tenons are not considered here, the general thickness of each rail being only required.

CAPITAL AND LABOUR.—V.

By J. E. THOROLD ROGERS, M.A., Tooke Professor of Economic Science.

ASSOCIATIONS OF CAPITAL.

IT has been stated that the assistance which capital gives labour—in order that labour may find its market, may be continuously occupied, and may be enabled to obtain an average remuneration, because it is not constrained to sell at a forced price, but may hold that which it produces till the market is better—varies with the nature of the operation on which industry is engaged. In some cases the assistance is so considerable that the labour would never be exercised if capital, in the hands of employers, were not forthcoming for the requisite purpose. In others it is so slight that the labourer can constantly dispense with the services of the employer, and deal at once with the public, or at any rate merely employ the occasional services of a middle-man or agent. The most obvious illustration of the latter phase is that in which a small occupier tills his own land by the labour of himself and his family. Here the only purpose for which he occasionally needs the office of the capitalist is to sell him such parts of his stock as he may wish to dispose of, and for the sale of which he finds it convenient to employ an agent in preference to going into the market himself.

But, on the other hand, there are certain kinds of industry in which it is impossible for the labourer to carry on his calling without the intervention of the capitalist employer. Such cases are (1) those in which great outlay is necessary previous to the exercise of labour in the service or production on which the labour is ultimately exercised; (2) those in which the economy of production, on a large scale, is so great that no individual labour would be able to compete against combined labour directed by the capitalist employer; (3) those in which it is

particularly needful that the turn of the market should be watched, in order to prevent great changes in the price of the article, and consequently great uncertainty in the amount of employment and the rate of wages.

One of the best illustrations which can be given of the first among these operations is that of the construction and maintenance of public roads, especially those with which we are familiar, in which the minimum of friction is overcome, and therefore the greatest speed can be obtained in travel, at the least possible expense. Now the construction of railroads is an operation of so much magnitude, that it is only in this country and the United States that railroads have been made by private and joint-stock enterprise. In every other country they have been constructed either wholly or partially by the State. In the wealthiest Continental countries it has been generally the custom for the State to supply the land, and for the company to construct the line. But in most cases the State has taken in hand the construction of railways, and of course has generally borrowed the necessary capital from foreigners. The magnitude of the operation has been so immense, and the resources at the command of the inhabitants have been so scanty, or the tendency to conjoined enterprise has been so feeble, that private agency would have been insufficient for the purpose. It may be added, too, that except in countries which possess great social and political freedom, and in which the use of this freedom has long been a familiar fact, it is very difficult to develop that spirit of mutual confidence which is requisite to the success of such undertakings. Even in countries where such confidence prevails, advantage has been taken of opportunity in order to abuse public trust for private ends. Both in our own country and in the United States a special kind of dishonesty and fraud has been practised in connection with railway enterprise, to the infinite disaster of those who have been interested in these undertakings.

Speaking roughly, English railways pay a dividend, at the present time, of about 4 per cent. on the capital invested in shares. The working expenses, on an average, and in the same general way, amount to nearly as much as the dividends. Hence the original outlay of the undertaking amounts to about ten times the quantity of the annual receipts—a proportion which is far in excess of that which rules in any other business. This fact will show why it would not be possible for private enterprise, apart from association, to have undertaken these roads, even if the magnitude of the undertaking had not been far beyond the resources of any private fortune. An individual trader expects that his capital will be replaced with its profit within a comparatively limited time, and would seldom, if ever, acquiesce in employing it in such an occupation as would return it only after an interval of ten years or more.

It may be worth while here to notice the fact that when persons invest their savings in undertakings to which they do not give their personal attendance, supervision, or labour, the advantage which they derive from such investments continually tends to the ordinary rate of interest. In other words, persons cannot get the profits of trade unless they take the risks and undertake the labour which trade implies. At the present time railways pay a somewhat higher per-centage than the ordinary rate of interest. But up to the beginning of last year (1871) they did not on an average pay a higher rate of profit to the shareholders than that which is obtained in public securities, and this profit was certainly liable to far more risk. I mention this partly because it is an important fact, the reason of which can be easily detected, and partly because it forms an illustration of the theory which I have already laid down, that the profit of such persons as are engaged in a business to which they give their personal labour is only wages under another name.

The office of the capitalist employer is also necessary when the calling on which labour is engaged is of such a kind that great economy may be effected by the division of employments, and therefore the individual labourer cannot compete against combined labour, directed by a capitalist employer. These economies are in the main twofold. In large undertakings of the class referred to it is constantly found possible to introduce labour-saving machines on the largest scale. Take, for example, the business of a man who is engaged in supplying builders' fittings—as doors and window-frames. Ordinarily, such work is the business of a joiner; but a wood-cutting machine will turn out a door or a window-frame—which would cost a day's work to the joiner—in a very few minutes, and will execute the work with almost mathematical precision. The planing machine of the machinist, employed to bring the surface of iron castings to the smoothness requisite for a well-constructed machine, is so prodigious an economy that no hand-labour could possibly compete against the machine. The second economy is that of classifying labour. In a great glass manufactory there are several classes of labour, the wages of which vary from pounds a week to shillings. If the industry were carried on by an individual, even if the individual were able to supply the costly plant and furnaces needed for the manufactory, it would be necessary for him to do the cheapest or meanest, as well as the dearest and mostly highly skilled labour himself. The waste of such a system is manifest.

In these callings, as the economy of a great as opposed to a small undertaking is manifest, there is a growing tendency to associate a large number of capitalist employers together, or, in other words, to turn private business into joint-stock enterprise. For the reason which I have given above this tendency will, I think, be temporary only, for it will very rarely be the case that joint-stock enterprise, unless it involves exceptional risk, will pay a much higher income than the ordinary rate of interest to those who engage in it.

Lastly, there are callings in which the turn of the market has to be carefully watched. Perhaps no better illustration of this kind of business can be given than the calling of a publisher of such books as are issued in order to meet the taste or caprice of the public. I cannot conceive the development of the joint-stock system among authors, or even among those who act as intermediaries between the author and the public. But it is quite certain, whatever may be the difficulties which lie in the way of any association of capitalists in this business, that there is no article in demand the value of which is so precarious as that of a book is, unless, of course, the reputation of an author is so grea that he can afford to write nonsense.

PRACTICAL APPLICATION OF THE FINE ARTS.—XIV.

By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING.

CLASSIFICATION OF BINDINGS—MATERIALS FOR BINDINGS.

Leathers.—Bindings are classed according to the outside cover. This may consist of various leathers, cloth or paper. A book may be whole-bound or half-bound. The whole-binding naturally means that the whole of the cover of the book is covered with the same leather. The half-binding is understood to mean that the back and corners of the book are covered with some leather, whilst the side simply has cloth, paper, marbled or otherwise, pasted on the boards: we have seen a book half-bound in Russia, with vellum sides.

Paper is only used for the commonest and cheapest of books, such as cheap novels. These paper covers are usually printed and ornamented with pictures or titles, and they are most frequently pasted first on the boards and back, and the whole, boards, back, and paper cover, attached to the book after it has been stitched and cut. This, of course, is the cheapest and least useful kind of cover that a book can have. Formerly, books were commonly sold in what were called boards, that is, the cover was just covered with a thin kind of dark-brown paper. Since the introduction of cloth for the first covering of books, "boards" have disappeared. The Italians had a rough paper binding also, which was called *alla rustica*, but it wore out very rapidly, and soon became useless.

These various coverings were used as cloth is now used for publishers' bindings, that is, for the covers in which books are prepared for their first sale. Of course, in this case a large number are done at a time all alike, or all having much of their ornamentation in common. The process by which this is done is somewhat different from that of binding proper, in which each book receives individual attention, and is treated, as lovers of books would have it treated, like a pet child. We shall in a future paper describe the wholesale binding in cloth, so that we defer that process for the present, and treat only of the individual binding.

Morocco.—Of all the leathers used for bookbinding, morocco

is undoubtedly the best. It is a carefully-prepared goat-skin, tanned, tawed, dyed, and grained. It is stronger, more pliable, and lasts longer than any other skin. Of this leather there are various kinds, and it is prepared in various places; English, French, and Spanish moroccos all excel in their own way, either in grain or in colour. The French have the pre-eminence in the species of *levant** skins, which are called *gros grain*, and are marked with a handsome full grain of considerable size; shagreen is a smaller marked skin which they also make, but which is made in England as well; whilst the English excel in the straight grain, which appears something like the wrinkles on the back of a man's hand. This grain is made by passing a ball of boxwood, with grooves in it, over the skin many times. As regards colours, the French produce the best light colours, especially reds and blues; their reds are far better than any manufactured in this country; whilst for darker tints, especially olives, maroons, greens, and browns, the English skins are esteemed preferable. The Spanish skins are coloured in a peculiar manner which somewhat resembles marbling, one colour being laid on another, and sometimes a third added in a similar manner. The mode in which this done is unknown, and skins coloured in this manner are only procured from Spain. The effect of this style of pattern is pleasing, but it is seldom employed now, except for Spanish books. The thick, good, and strong skins of morocco frequently cost as much as £1 apiece, and they will after all serve only for the binding of one large book, as merley the best parts of the skin can be employed, though, of course, the scraps cut off can be applied to less important purposes. A thinner and cheaper kind of morocco is used for the pieces put on either as labels at the back, or for inlaying the sides of a book, but this is not suited for covering the whole of the back and boards. In working morocco after it is put on the book, it is found that it should be prepared for the finisher by damping it. The reds are greatly improved by the addition of a little acid, whilst other colours work best when moistened with diluted vinegar, but if the colours are very light a little pure water is the best medium.

SPECIMEN OF BINDING, NO. 2.—FRENCH.

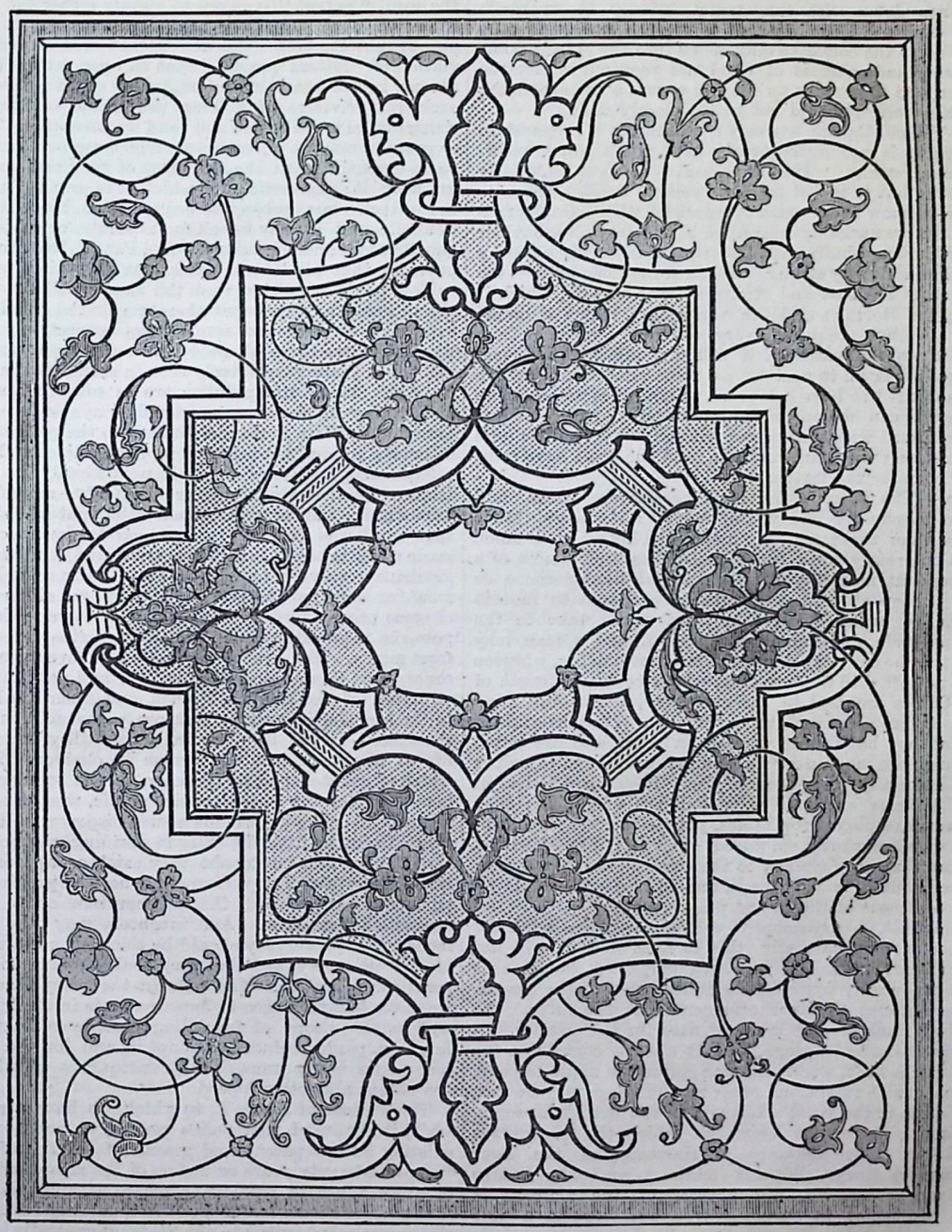
SPECIMEN OF BINDING, NO. 3.—FRENCH.

Russia.—Russia leather is prepared from various kinds of skin, and has a very pleasing odour; the appearance of the lines in it is agreeable, but it has the unfortunate peculiarity of requiring to be kept under cover; for if it is exposed to the atmosphere of London, combined with the results of the combustion of gas, it is observed that Russia very soon becomes discoloured; it dries up, and at last crumbles to powder. An instance of this kind occurred not very long ago at the Athenæum Club-house, where it was found that a large number of valuable bindings had completely gone. This is a great drawback to a species of binding that otherwise would be most agreeable.

Calf.—Calf is really what it is called, the skin of the calf, pre-

* It is remarkable that both the terms *morocco* and *levant*, which now designate a peculiar kind of leather, manufactured in London or France, should have so far changed their original signification; but these are only two out of numbers of words, which from geographical names have become designations of manufactures, and the materials being cheaper elsewhere, the productions themselves are imported to the countries whence they take their names.

pared by the process called by tanners "tawing." The natural colour of the skin is a very light drab, but it turns darker in time, and becomes a light-brown. The uncoloured skin is pleasant enough to the eye, and is used in the peculiar style of binding called "Law," since it is commonly used for law-books.



SPECIMEN OF BINDING, NO. 1.—GROLIER.

The skin, however, can be dyed any colour, and it has then an agreeable appearance, but as the mordants used in the dyeing are apt to attack the leather, and cause it to go more than it otherwise would have done, the best style of decoration for calf is the colouring of the natural skin by the binder. There are various ways in which this is done. It may be sprinkled wholly or in part. This is effected with a hog's-hair brush, dipped in a strongish solution of copperas (protosulphate of iron) in water; the brush is scratched with the nail, and the small drops are allowed to fall upon the cover, or upon a portion of the cover, the rest being protected by a covering. The copperas mixing with the tanning left in the skin produces a kind of ink, and so darkens the spot where it falls. Considerable variety may be caused by protecting various portions of the cover in patterns, and graduations of the colouring can also be effected. Another mode of colouring is called *French catspaw*. This is produced by dipping a piece of wool, or similar substance, in the colouring matter, and dropping it on the cover, thus forming a more or less regular series of patches of dark colour. A third style of ornamentation is called "tree calf." The process by which this curious style of ornamentation is brought about is almost as remarkable as the marbling the edges of the leaves. The cover, which, of course, must not be too thick, is bent upwards away

from the book into the form of a channel. This is held slanting, at an angle, say, of thirty degrees: it is then sprinkled with pure water pretty freely, until the various spots begin to run into one another, and to find their way down to the central channel, and thus to fall off the cover. At this moment some very finely powdered copperas is dropped on the wet spots, and allowed to run down with the stream. Where the water is sufficient it carries off the iron, but where the leather is only damped it allows the colour to sink down into the skin. Some little experience and neatness of hand are required to give the desired effect, and to produce on the two covers a corresponding effect, which, however, should not be too closely alike.

Vellum.—Vellum, though scarcely a leather, is a preparation from skin which is not unfrequently used for binding, particularly classical works. The appearance at first especially is very pleasing, but it is apt to grow yellow, besides, from its colour, liable to show every stain or speck of dirt. Gold ornament stands out remarkably well upon the plain white, but for every-day use such a binding is almost painful. This covering lasts very well, and is very strong. There are various kinds—the English, which is the best and strongest; the artist's, which is the whitest; the Roman; and the commonest, which is called parchment. Vellum requires very different working from morocco and the other leathers; it will not admit of inlaying, for all leathers stuck on it peel off as soon almost as they are dry. If it is desired to have colour on vellum, it is necessary to paint it, and this can be done with plain water-colours. Vellum has to be moistened with pure water with only a very little gum in it; it requires a very clean workman, and the tools have to be much cooler than for the leather.

Sheep, etc.—The other skins used are sheep, roans, and skivers. *Sheep* may be had white, and of all colours. It is much thinner than those we have mentioned before, and much cheaper. It is greatly used for school-books and works of a like character, but naturally it will not last like morocco or even calf. Sheep-skins are sometimes prepared to imitate morocco, and so successfully, that they would take in the unwary. The grain and colour are perfect, and a man may often think that he has bought a cheap morocco binding, whereas he has been put off with a sheep-skin, which costs one-fourth of the price. Calf is imitated in the same way, and to the same effect. *Roans* are prepared much like the straight-grained morocco, but they have more varnish on them, and are much thinner. These are much used for binding and for half-binding periodicals, especially those of large size. Roans can be had in all colours. *Skivers* are split skins, and are very thin; they used to be much employed for Bibles, prayer-books, and school-books, and then frequently embossed—that is, stamped with a pattern before they are fastened to the covers. *American cloth* has been used, but it is very weak, and is now only employed in the cheapest forms of Bibles and prayer-books.

Velvet and Silk.—Occasionally velvet has been used for covers of books, but, naturally, this is rare, since it will not stand much wear. Silk also has been employed, but this is much more frequently found in the inner sides of the boards, which are sometimes as much ornamented as the outer. We have seen both vellum and morocco used for the interior, but the latter has the disadvantage, that it always contains some fat, which, after a time, works out and stains the opposite page. Several specimens of velvet and other rare bindings may be seen in the open cases in the King's Library, in the British Museum. Amongst others, there are some, of which the covers are embroidered; we may instance a Harmony of the Four Gospels, bound by Mary Collet, for Charles I., in 1635; twelve paintings upon vellum, by Julio Clovio, of the victories of Charles V., are bound in purple velvet, and kept in a blue morocco case; this belongs to the Grenville Library, the whole of which is preserved in excellent bindings. Of embroidered velvet we may instance Queen Elizabeth's copy of Archbishop Parker's "De Antiquitate Britannicæ Ecclesiæ."

We have now detailed all the various coverings ordinarily put upon books, except the commoner sorts used by publishers, viz., cloth and paper; but as the binding with these is a distinct art, requiring in many points a description to itself, we shall reserve this for a future paper, in which we shall also give some account of the stove and tools used by the "finisher" in ornamenting the back and sides of a book with lines and figures of various kinds in gold.

PATENTS AND PATENT LAW.—II.

By A Barrister.

A PATENT: WHAT IT IS, AND WHAT ITS SUBJECT MAY BE.

We now proceed to discuss what a patent is, and what may be the subject of a patent. According to ordinary acceptation, the word "patent" is taken to signify either the letters patent by which the monopoly is granted, or the subject-matter of the grant; but the best definition speaks of it as merely an abbreviation of "letters patent," that is, open letters (*patentes*). A patent, in this sense, therefore, is the grant by the State of the exclusive privilege of making, using, and vending, and authorising others to make use and vend an invention. The monopoly so granted may be unrestricted in geographical extent, and thus be co-extensive with the authority of the State or Government granting it; the period for which it is granted is now limited to fourteen years, subject to prolongation, by order of the Privy Council; and it may be either absolute, or subject to certain qualifications and conditions. The Patent Law Amendment Act provides that all letters patent for inventions shall be made subject to the condition that the same shall be void, and that the powers and privileges thereby granted shall cease at the expiration of three and seven years respectively from the date thereof, unless there be paid before the expiration of the three and seven years respectively certain stamp duties mentioned in the Act. These stamp duties are in substitution for the fees and duties which were previously payable on taking out a patent. Further, it may be limited to the patentee personally, or extend to him, his personal representatives and assigns.

The early statute of James I. used simply the word "manufacture" as the subject-matter of patents—manufactures which others at the time of making such letters patent did not use—and that word was generally understood to denote either a thing made which is useful for its own sake, and vendible as such, as a medicine, a stove, a telescope; or to mean an engine or instrument, or some part thereof, to be employed either in the making of some previously known article, or in some other useful purpose, as a stocking-frame, or steam-engine for raising waters from mines. The French law extends to every invention or discovery, and in any kind of industry; and yet the practical construction of the English, French, and American law, in regard to the kinds of inventions that are patentable, is substantially the same. It will be observed that utility is essential to the life of a patent, and the reason is obvious. The monopoly which is granted to the inventor, is not so much for his own benefit as for the benefit of the public, who encourage him by rewards to make known his secret discovery. There can, as a general rule, be little difficulty in deciding whether an invention is useful or not, but doubt may exist, as appears by a recent case before the Privy Council, where a prolongation of the monopoly was refused, the presumption as to utility being against the invention. And inventors may take it, that before incurring expense, they should be tolerably certain of the utility of their discovery, and that they shall be able to carry it into practical operation. The case in the Privy Council to which we refer had reference to improvements in electric conductors, and in the means of insulating electric conductors; but two large companies refused to adopt it, and for the whole of fourteen years it lay unused, the consequence of which was that the patent altogether lapsed.

The statute of James I., to which we have already referred, while it abolished monopolies generally, made an exception of existing letters patent and grants of privilege for the term of "one-and-twenty years or under, of the sole working or making of any manner of *new* manufacture within this realm to the *first and true inventor* or *inventors*, so they be not contrary to the law or mischievous to the State, or generally inconvenient;" and also an exception of future grants of letters patent for the term of fourteen years or under. Here we see that another essential of a patent is novelty. The subject-matter of a patent must be useful and new. But novelty must not be taken to mean new in all details, inasmuch as a patentable invention may be a new combination of materials previously in use for the same purpose, or a new method of applying such materials. This fact, however, must be made clearly to appear, as the mere application of a well-known process of casting to an article previously well known has been held not to be the subject of a patent. A very good illustration of legitimate operations in

this respect is afforded by the discovery of electricity, which has presented a variety of applications to practical purposes, and opened an immense field for the granting of patents.

An important consideration arises as to the period to which the term "novelty" is to apply, and it would seem sufficient if it appear that the thing patented had not been known or used before the *invention* by the patentee, as distinguished from the time of his application for a patent. The actual issue as to novelty is not so easily decided as might be supposed, and may present a difficult problem of mixed law and fact for solution by the judges. So closely may different descriptions apparently refer to the same subject, and yet in truth refer to inventions having different operations, that it is only by careful inquiry that novelty can be established or disproved. In one case, it was laid down, that even if there be identity of language in the specifications, yet if there be terms of art in one and also terms of art in the other, it is impossible to predicate of the two with certainty that they describe the same identical external object, unless it is ascertained that the terms of art used in the one have precisely the same signification, and denote the same external objects, at the date of the one specification as they do at the date of the other. Therefore, evidence must be forthcoming on these points. Further, an invention may be novel which is new in its practical operation, though the theory upon which it rests has been described in a prior specification. Thus, it has been distinctly held, that a notion that tin and lead might, by means of pressure, be so combined as to form a new and useful material, without giving information how to attain that object, is no ground for invalidating a subsequent patent giving that information. In delivering judgment in that particular case, the then Lord Chancellor was very precise, and well states the established rule, "that a barren general description probably containing some suggested information, or involving some speculative theory, cannot be considered as anticipating, and therefore as voiding for want of novelty, a subsequent specification or invention, which involves a practical truth, which is productive of beneficial results, unless you ascertain that the antecedent publication involves the same amount of practical and useful information."

An interesting illustration of what has been said on the subject of novelty has reference to chemical processes, and it has been distinctly held that where a patent has been taken out for improvements in the mode of producing a chemical substance, it is no bar to the legal validity of the patent that the subject of the patent is a product already known to scientific men, provided the patentee is the first person who has produced the substance in a sufficient quantity to make it a marketable article. And it was further decided in the same case that it is no bar to the validity of a patent for improvements in the mode of producing a particular substance that similar processes have been employed to produce analogous substances, where the subject-matter of the production is a chemical product, and the process is a chemical process. And further, that where the subject-matter of an alleged invention is an improvement of a chemical process for the production of a substance, a patent specifying a particular limit of temperature to be used in the process may be valid. But there cannot be a patent for a philosophical principle only.

We should occupy too much space were we to elaborate this particular branch of the subject by referring to the numerous decided cases, and we will now proceed to another necessary condition to obtaining a patent. The applicant must be, in the words of the statute, the "first and true inventor." The inventor within the meaning of the patent laws has been described to be the man who discovers the mode of producing the substance or material in such a form, and to such an extent, as to make it useful to the public at large. He is not the inventor who merely suggests, unless, indeed, he suggest the actual process or machine. If the specific process is pointed out, the person to whom it is pointed out cannot afterwards be the inventor. In an action by a patentee for an infringement of a patent for a bleaching liquor, a chemist deposed that previously to the granting of the patent he had had frequent conversations with the patentee on the means of improving bleaching liquor, and that in one of them he had suggested to the patentee that he would probably obtain his end by keeping the lime-water constantly agitated; it appeared that this was indispensable in the process, and consequently Lord Ellenborough refused to recognise the patentee as the first and true inventor. Again, where a workman made an improvement, and his master patented it, the latter was held not entitled to sue for an infringement. But it is a question to be decided, upon consideration of the particular circumstances, whether the inventor by the nature of his employment, or by his contract, either assigns his invention to his employer, or at least divests himself of his property in it. If a person is employed for the express purpose of devising improvements, anything which he invents in the course of his employment is, it appears, the property of his employer.

A difficulty may suggest itself where there are simultaneous inventions by different persons. The case has arisen and been decided, and the decision is that he who first publishes his discovery by obtaining a patent for it will be the true and first inventor within the meaning of the statute, although he may not actually have been the first to make the discovery. Then again, is a person who obtains information abroad, and takes out a patent in this country, the first and true inventor? He is, and it is no objection that the patent is taken out in trust merely for the foreign inventor. But by a recent enactment it has been expressly provided that where letters patent are granted in the United Kingdom for any invention first invented in a foreign country, or by the subject of any foreign State, and a like privilege for the exclusive use or exercise of such invention in any foreign country is there obtained before the grant of such letters patent in the United Kingdom, all rights and privileges under such letters patent shall (notwithstanding any term in such letters patent limited) cease and be void immediately upon the expiration or other determination of the term of the like privilege obtained in such foreign country; or where more than one such like privilege is obtained abroad, immediately upon the expiration or determination of the term of such privileges which shall first expire or determine. And no letters patent granted for any invention, for which any patent or like privilege shall have been obtained in any foreign country, shall be of any validity if granted after the expiration of the term for which the foreign patent or privilege was in force (15 & 16 Vict., c. 83, s. 25).

Before proceeding, as we shall do in our next paper, to show how letters patent are obtained, we may mention generally that they are not by any means granted as a matter of right. The granting of letters patent is a prerogative of the Crown, and although a patent may now be always obtained for a new invention, yet the grant is still a matter of favour, and not of right, and all grants are clogged with certain conditions, to which we shall have to refer in some little detail. And when granted for the period allowed by the statute, the question of prolongation is one purely of discretion for the Privy Council. In a very recent case, the specification of a patent described it as an improvement in treating, deodorising, and disinfecting sewage and other offensive matter, and also for deodorising and disinfecting in general, and as being composed of two ordinary well-known chemical acids in combination, such acids being in common use for disinfecting purposes by the public before and after the letters patent. The invention was held not to be of such merit as to justify an extension, to the detriment of the public in the use of known sanitary agents. The Privy Council, however, has a fixed limit of fourteen years, beyond which it cannot grant a prolongation of a patent, and it may determine to grant an extension to any shorter period which the nature of the invention may suggest.

MAP AND PLAN DRAWING.—IV.

By C. C. King.

DELINEATION OF SMALLER AREAS.

In the previous papers we have very briefly examined the method on which surveys of large areas are conducted. Even when we have unlimited time and means at our disposal, so important is this branch of map-making, that great care and the most accurate instruments are required to efficiently carry out the operations. But in the delineation of smaller extents of country the chances of error are reduced; and in the construction of these plans less perfect means are employed, though, at the same time, care is equally necessary, and sufficiently correct

results can then be obtained for all practical purposes. It is not, however, advanced that the theodolite and level are unnecessary in this work, for whenever time or opportunity is afforded they may be used with advantage; but we shall endeavour to point out how, with very portable instruments, the survey of a small area is conducted, and how, with care, such may be both valuable and approximately true. We have, in defining the difference between a map and plan, described the latter as the representation of a less extensive tract than that to which the former applies; and plans, again, may be of two kinds—one of a comparatively large area, when it approaches the magnitude and nature of a small map, and when the method of construction will assimilate very nearly to that of a map, or the sketch of a very small space of ground, as, for example, a village or estate of a few acres, where triangulation would be perhaps difficult, through the want of prominent features, and in many cases unnecessary, as the distances could be accurately measured without going through the labour of ascertaining them by trigonometrical calculation. The second case, in fact, merely comprises the work done in the concluding portion of the first or larger plan—that is, in one instance the principal points or "bench marks" are determined by triangulation, and in the other by absolute measurement, if it appears to save time and trouble during the operations of "traversing," which will be explained later.

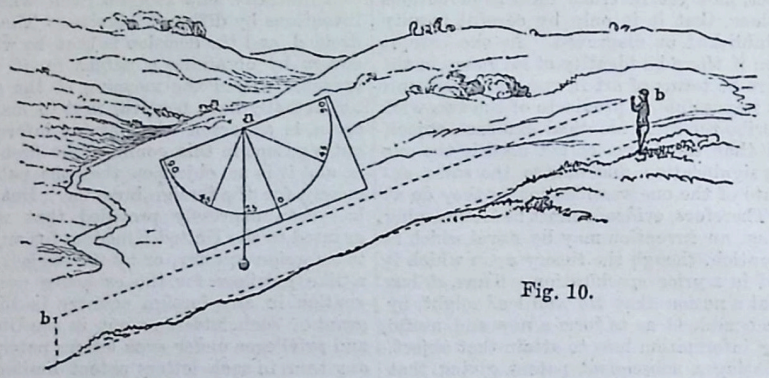


Fig. 10.

The instruments to be employed will necessarily have to perform the same kind of work as in more extended surveys—that is to say, a base has to be measured, triangles have to be constructed, heights have to be ascertained, and means of carrying out these requirements have to be provided. Those used in sketches of this sort are the prismatic compass, for reading angular bearings; the chain, or even a well-stretched and carefully-prepared line, if no chain be procurable, for measuring distances; the clinometer or orometer, for levelling and finding altitudes; and, lastly, a plotting-book and sketching-case.

In map making, that is, in extensive delineations, the "plotting" or note-book is alone used, as it would be impossible to transfer the work done in the field actually to paper, because of the size of the measurement; but in the present instance the plan, with any ordinary scale, is sufficiently small to come within the limits of a moderately-sized sketching-case; and though the note-book may be used to check the observations, it is advisable to transfer the work done, especially if time be an object, immediately to the field sketch, from which, if it be afterwards required, a copy can eventually be made. The plotting-book is a simple rectangular note-book, some few pages of which may be ruled to put down the series of angles in a triangulation, in the manner exhibited in the accompanying model;

Station.	1st Observn.	2nd Observn.	Remarks.
A	42° 15′	42° 15′ 30″	Bearing of windmill.
B	108 20	108 20 0	Bearing of St. Andrew's Church.

and the remainder ruled on each page, with two parallel lines which run along the centre of each page and divide it into three equal, narrow spaces, the use for which will be explained further on. The sketching-case may be of any form, but the most convenient kind is that which is provided with a slight metal frame for keeping the paper down in its place, on a pasteboard block, and which is further provided with a cover of some waterproof material, capable of being secured by elastic bands, over the sketch, and also with a leather strap at the back of the case, for the purpose of slinging it over the shoulder or round the neck, thus leaving the hands free for using instruments. The paper for prismatic compass work is ruled either in pencil or with pale-blue ink, with a series of parallel lines at irregular intervals. This is designed for the use of the prismatic compass and protractor, as will be seen in describing the method of depicting the work done. The protractor is a rectangular piece of ivory or wood, the edge of which is divided into 180°, and which has also a series of equidistant lines ruled on it, parallel to its shorter side. For convenience' sake a few scales, such as would be most generally useful in work of this nature, are marked on one side of the protractor.

The chain has been described in former papers, but any piece of well-stretched and carefully-dried cord can be used, and sufficient accuracy arrived at by repeated measurement. In many cases the pace of the surveyor is used for determining distances; and in military work this is invariably employed to a large extent; but care must be taken that the pacing is regular, and that allowance is made for irregularities of ground in ascending or descending hills or valleys.

The clinometer is a portable instrument for measuring inclinations of slopes, or even for tracing a horizontal contour line through the district; but as it is carried in the hand, and is therefore susceptible of any sudden irregular movement of the operator, and is also liable to be disturbed by wind, great care is required in its use, and the results arrived at by it are necessarily only approximately true. There are many varieties of clinometers, the simplest and most general form being a rectangular piece of wood or cardboard, three sides of which are graduated in degrees, on an arc of which the middle point of the upper long side is the centre; and to this point is attached a silken cord and plummet which, hanging vertically, aligns itself with one of the angular divisions and indicates the slope at which the upper edge is inclined. There are two methods of using it, either by making the upper edge parallel to the slope of a hill, seen as it were in profile (Fig. 10, *a*), when the flat side of the instrument is towards the observer; or by looking along the upper edge, either up or down hill (Fig. 10, *b*), and when its prolongation passes through a point the same height above the slope observed as the eye of the operator, reading the angle indicated by the plumb-line. It is evident, in the latter case, that practice is essential to ensure the upper edge being in a plane parallel to the slope of the hill. For contouring it is simply necessary to keep the plummet vertical through the zero point, which is immediately opposite to that whence the cord is suspended, and then notice where the prolongation of the top side of the rectangle, which is therefore horizontal, meets the sides of the hills or valleys (Fig. 11, *c*). These points should be marked temporarily by a stone or picket.

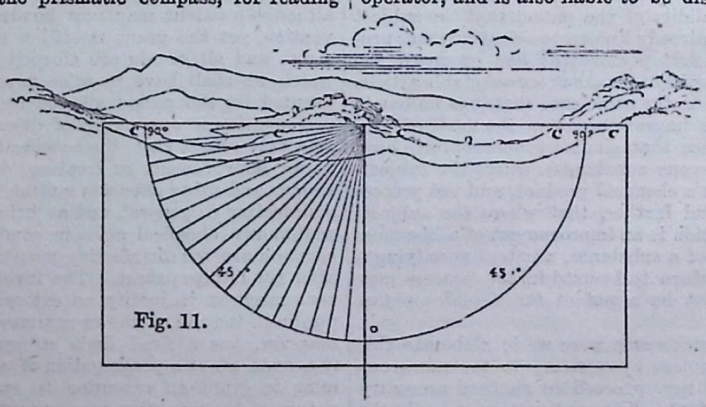


Fig. 11.

From the clinometer we will now pass on to describe the prismatic compass, which is, as its name denotes, an instrument for measuring angles with reference to the magnetic meridian. There is a great difference, therefore, between a series of angles taken by it and by the theodolite. With the latter the round of angles is taken with reference to the line on which the zero point of the instrument is directed. Thus, if the theodolite be placed at one extremity of a base, and the telescope be directed on the other extremity, the angles will be measured from that base, and will be those contained between it and the lines joining the several points observed with the station on which the instrument is placed. But in using the compass, the angles taken at any period have reference to the magnetic meridian, and are those contained between it and the lines uniting the observed points with the surveyor's position. It consists of a brass box, in which is a common compass-card, capable of free movement on a needle-point. The edge of the card is graduated in degrees from zero to 360°; and as these are read through a prismatic sight attached to one side of the box, the numbers are printed the reverse way. This prism is contained in a small brass case, working on a hinge, so as to admit of its being brought vertically over the edge of the compass-card, and has, when so placed, a notched "sight" on its upper surface. Immediately opposite this sight, and on the line, therefore, passing from it through the centre on which the card turns, is a small brass frame, which moves on a hinge, so as to bring it into a vertical position, and which contains a fine wire, carefully aligned by the maker, at right angles to the plane of the compass when held horizontally. Thus, if the eye be kept close to the notch of the prism, and the line of sight be directed, by means of the wire, on any given point, its bearing with reference to the meridian can be read on the card, through the prism, without removing the eye from the sight. The compass having free movement, is always seeking to point to the magnetic north, and to check its oscillation and cause it to remain stationary in that direction, a small spring, which can be pressed against the edge of the card by the finger of the operator, is attached to the front side of the box. For field-work a good pencil is an absolute necessity, and for all ordinary purposes, an F or a HHH, if good, are the best kinds, with perhaps a darker one, in case any of the hill shading is done in the field; and as a practical fact it is advisable that these, together with the india-rubber and penknife, should be attached by cords to the sketching-case, as the surveyor frequently works independently, and in moving over rough ground may suddenly find himself unable to continue his work, owing to the loss of his materials for noting down or transferring to paper the observations and results he has obtained.

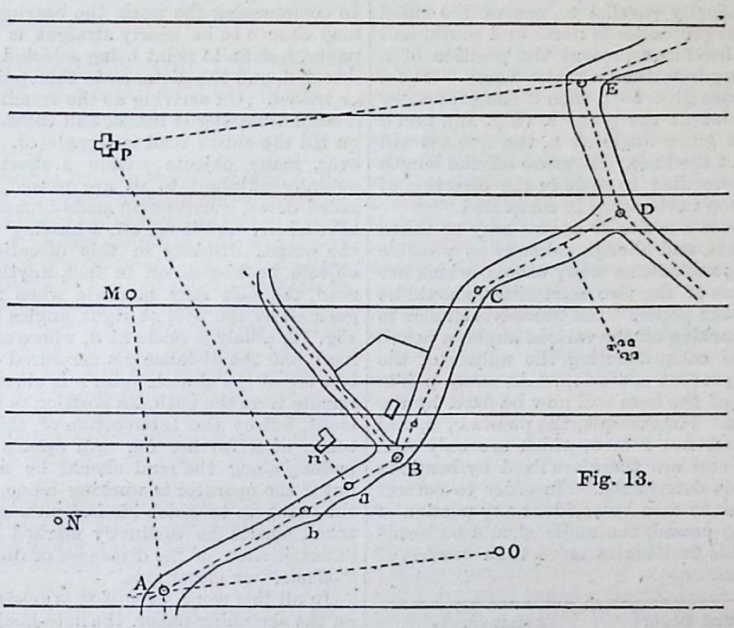


Fig. 13.

Let us assume, then, that the surveyor having walked over the area he intends to survey, so as to acquire a general knowledge of its features and of its extent, has finally selected a piece of tolerably level ground, conveniently situated in a somewhat central position, on which to measure his base. Choosing two points as far apart as possible (for on the length of the base much of the accuracy of his sketch will depend), and from which a tolerably numerous series of points can be seen, he marks them by pickets firmly planted in the ground, and proceeds to measure or pace the distance between them as often as may appear necessary. Should there be much difference of level between them, the angle of depression will be measured by the clinometer, and the base transferred to a horizontal plane by a simple trigonometrical calculation.* It is not absolutely requisite that the base should be so situated as to admit of all the prominent points in the neighbourhood being visible from its extremities. It may happen that the most convenient site for it is in a valley; but from it one or two points that afford a more extended view should be apparent, probably on nearly adjacent hill-tops, and these, when carefully determined by observation, will constitute, in some respects, a secondary base.

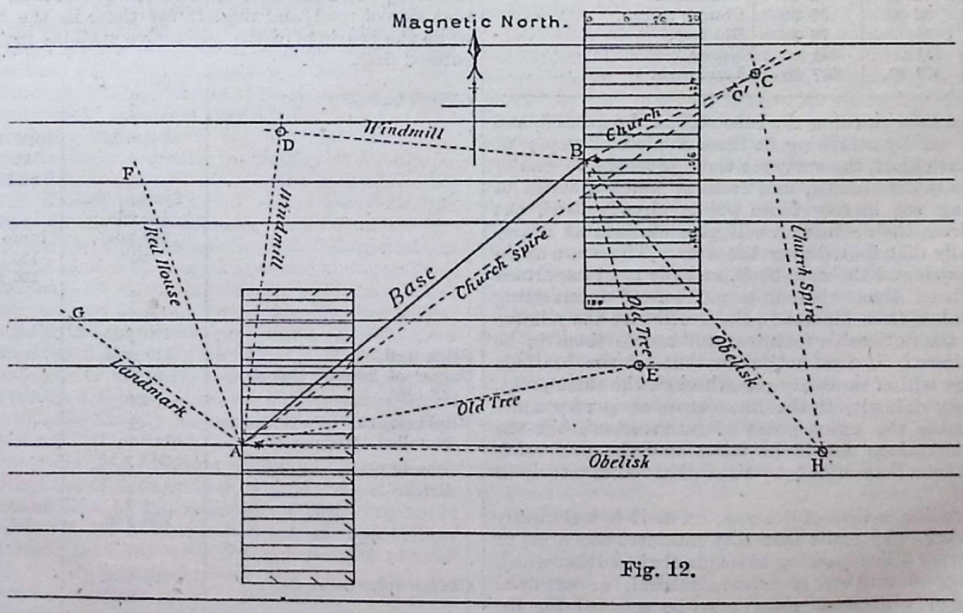


Fig. 12.

The magnetic bearing of the base is then observed, and according to the selected scale the base is transferred to paper.

* The required distance in this case is manifestly the base of the triangle, of which the actual measurement is the hypothenuse, and the angle at the base that ascertained by the clinometer.

The blue or pencil lines ruled on the prepared sheets are usually considered as magnetic east and west lines, and all lines at right angles to them are therefore magnetic north and south. Marking any convenient point on the paper to represent one extremity of the base, the protractor is placed with the zero mark at this point, and with *one* of the transverse lines marked on it coinciding with, or exactly parallel to, one of the ruled lines. Thus the edge of the protractor is north and south, and any angle measured will therefore represent the position of a point with the given bearing from the magnetic north. Thus, let the reading of the compass give 50°; then if the protractor be placed with the zero point at the point A (Fig. 12), and a mark be made opposite the given angle at B, the line A B will give the required direction of the base. Measure off the length of the base as ascertained according to scale in the direction of from A to B, and the first step in the work is completed.

From both ends of the base a series of angles may be taken at the most prominent points, and though as many as possible should be seen from both positions, as many others, which are only visible from perhaps one of the two extremities, should be observed and transferred to the paper. The process is similar to the previous one; but in marking off the various angles a pencil remark should be affixed to each, denoting the nature of the object referred to, so as to prevent confusion. As many points as are seen from both ends of the base will now be fixed by the intersection of the bearings. For example, the points C, D, and E have been determined, but not F or G, which are only seen from the point A (Fig. 12), and are therefore fixed by bearings from other points afterwards determined. In order to correct the work, and not be at a loss in case by accident any portion of the drawing should become erased, the angle should be noted in the note-book; and in this first series more than one set of observations should be taken.

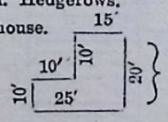
Position.	1st Obsn.	2nd Obsn.	Remarks.
Point B (east end of base)	230°	230°	Point A. West end of base.
	275	274	Windmill.
	62 30′	62	Church spire.
	196	196 30′	Old tree.
Point A (west end of base)	6 30′	6 30	Windmill.
	53 30	53 30	Church spire.
	79	79 30	Old tree.
	341	341	House.
	307 30	307 30	Landmark.

Leaving the pickets marking the base still in the ground, and distinguishing them by attaching to them a piece of paper or some conspicuous object, the surveyor then proceeds to one of the points already determined, and from it takes a series of angles embracing not merely those points already fixed, but such others as from their situation will give stations as nearly as possible equally distributed over the area. These are again transferred to paper and the note-book, and the most important places having been thus visited, a number of intersecting lines, bearings taken from different points, will give the relative positions of all the noticeable features, and enable them to be accurately laid down. It does not follow that all the bearings of any one feature will of necessity pass through the same point, as it is extremely difficult, if the lines cross at a very acute angle, to determine the exact point of intersection; but the mean of the observations should be taken, and the preference given to the points determined by lines that cross nearly at right angles.*

The next operation is that of tracing, or, as it is technically called, "traversing" any roads that may intersect the area, or if none be present, a line passing through that portion which contains the largest number of minor, natural, or artificial peculiarities. Any convenient place may be selected for the starting-point; and this, if it should not happen to be a station already fixed by bearings, may be readily marked on the plan by "interpolation." The bearings of two or three of the points previously determined are taken and noted down. These angles are then laid off from the points on the paper to which they refer, and the prolongations of these lines will give, by their intersection, the true place of the observer. Thus, in Fig. 13, if the road there traversed did not start from a known point (N), the situation of A would be ascertained by taking bearings of M and O, and measuring off the angles at these points: it will be seen that their intersection gives the required station. In commencing the work, the bearing of as much of the road as may chance to be nearly straight is taken and laid off on the paper, a definite point being selected on which the instrument is directed, and the distance to this point is then either measured or traced. On arriving at the termination of this measurement a second bearing is taken, and the same course pursued, and so on till the entire road is completed. In proceeding thus, however, many objects within a short distance of the road, or actually adjacent to it, are passed, and these are successively noted down, a halt being made in measuring when such a feature is reached; and if far off, a bearing is taken only; but if near, the actual distance in this direction is ascertained. If the objects be houses, or, in fact, anything that is very near the road, the halt may be made when it is, as nearly as can be guessed by the eye, at right angles to the line traversed. In Fig. 13, a halt is made at *a*, where a house is bordering on the road, and the distance *a n* measured or paced. Again, at *b*, the bearing of the church spire P is observed, but as it is somewhat remote from the path, its position is not determined by measurement, but by the intersection of this observation, and another taken at E further on. All details that can be examined in passing along the road should be measured and noted down, but if the operator is working alone, care must be taken that the point up to which his last measurement on the traverse was taken should be distinctly marked before he proceeds to the determination of the distances or dimensions, technically called "offsets," on either side.

In all this work, even if it is actually pencilled or "plotted" on the sketching paper, the note-book should be used, as much of the detail had better be drawn at a later period, to prevent the danger of the work being rubbed out.

The note-book, divided, as we have before indicated, into three equal parts, is opened, and the first entry made on the last page at the bottom, and the succeeding entries written up the page, reserving the right-hand side for those remarks which apply to that side of road, and the left for those in the other direction, while the bearings of the successive stations in the traverse are entered first.

Church bears 262° 30′.	Station E. ⊙ 140 yds. 343° 30′	
	⊙ Station D. 160 yds. 100 yds. 61°	Road bears 133° 30′. Width, 20′. Banks and ditches.
	⊙ Station C. 190 yds. 110 yds. 40 yds. 25°	Clump of trees. Bears 153° 30′. Distance 130 yards.
Brick wall. Corner of house. Wood, 60′+30′.		
Road bears 321° 30′. Width, 15′. Metalled. Hedgerows.	⊙ Station B. 260 yds.	
Corner of house. Brick. 	210 yds.	
Church spire bears 330°.	165 yds. 59° ⊙ Station A.	

It will be noticed that the total measurements from the point whence the last traversed bearing was observed to each halting place, are written down, and *not* the intermediate distances; and the same plan should be adopted in transferring the work to paper, as it prevents errors in drawing. For example, in marking down the position of points *b*, *a*, B, in Fig. 13, the distances A *b*, A *a*, A B, are marked, and not the distances A *b*, *b a*, *a* B.

* Thus the point C (Fig. 12) is better determined by the bearings B C and H C than from B C and A C, which appear to intersect at c′. H is determined from A and B.

All the roads are thus gradually drawn on the sketch, and the greater portion of the information we are seeking to obtain has then been relatively traced on our plan, without reference, however, to the physical irregularities of the terrain. It remains, therefore, to complete the work by representing the character of the country, and by fixing the altitudes of the different features in it.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVII.—CHARLES VON LINNÉ OR LINNÆUS.

BY JAMES GRANT.

THIS distinguished naturalist was born on the 3rd of May, 1707, at Rashult, a village in the province of Smaland in Sweden, where his father, Nicholas Linné or Linnæus, was pastor. Charles he destined to be his successor in the pulpit, a hope which was never realised. The old man was a professed lover of flowers, and in the little garden attached to his parsonage he contrived to collect and to cultivate no less than 400 specimens of plants, most of which were of foreign growth; so this darling passion of the parent was reproduced in the son, who, for want of playmates, made the garden the circle of his juvenile diversions, save when he wandered into the woods and fields in search of plants and flowers to enrich it. His father, in his hours of leisure, taught him Latin, theology, and geography; and further, to qualify him for the pulpit, sent him to school at Wexio in Smaland, in 1717.

There the slowness of his progress induced the professors of the college to furnish him with such poor testimonials, that his father lost heart, and resolved to apprentice him to a cobbler, a result which was prevented by Johann Rothman, a physician of Wexio, who, having detected the bent of mind in young Linnæus, urged that he might be permitted to study physic and botany. On this new career he entered with ardour, and Rothman became his teacher, and Tournefort's "Institutiones Rei Herbariæ," which he found in the worthy doctor's library, became, as Stoever tells us, "the torch which illuminated the path of the youth, and opened new prospects to his eager views."

On completing his twentieth year, he resolved to attend a university, and the slenderness of his means compelled him to fix upon that of Lund, in the province of Scania, where Kilian Stobæus, who was then professor of physic and botany, became as an oracle to Linnæus, and perceiving that his circumstances were poor, he kindly took him as a free-boarder into his own family. After studying botany hard day and night at Lund, he took his departure for the greater university of Upsala, at Michaelmas, 1728. Scanty though his means, he pursued his studies there with ardour, but the end of the year saw him without the smallest means of subsistence. His father was too poor to aid him, but his kind-hearted Swedish fellow-students did. Among them he picked up a meal here and there, and was glad to accept their cast-off clothing, while necessity compelled him on more than on one occasion to cobble his own shoes; thus having recourse to the very trade with which the old pastor of Rashult had threatened him. On the arrival of the learned Olaus Celsius, professor of divinity, this state of poverty was ameliorated. He received Linnæus into his house, and obtained from him much valuable literary assistance in the compilation of his "Hierobotanicon."

It was about this time that Linnæus conceived his great idea of creating a new system of botany, and by attending closely to the position or connection of the stamens, or male organs in plants, he arranged all vegetables under one of twenty-four classes, and each class into two or more orders. He showed that the *stamina*, or dust-threads, were the male, and the *pistilla*, or dust-ways, the female parts of the plants. The sexes of plants now occupied his thoughts day and night, and this new system, of which he was the founder, began to attract the attention of the learned world.

"The system of Linnæus rests," says Figuier, "upon the consideration of the organs of fecundation—organs almost overlooked until then, but whose physiological functions have since been ably demonstrated. He introduced at the same time a salutary and much-wanted reform into botanical language and nomenclature, defining most rigorously the terms used to express the various modifications and characteristics of the organs, and reducing the name of each plant to two words, the first *substantive* designating the genus, the second *adjective* designating a species of the genus. Before his time, in fact, it was necessary to follow the name of the genus through a whole sentence in order to characterise the species, and in proportion as the numbers of the species increased, the sentences were lengthened, until it seemed as if they would never come to an end. It was like the confusion which would arise in society if, in place of using the family name and surname, we were to suppress the baptismal name, and substitute for it an enumeration of many qualities distinctive of the individual; as if, for example, in place of saying Pierre Durand or Louis Durand, we said Durand the great sportsman, or any other phraseology applicable to the qualities of the individual. Nevertheless, the Linnæan or binary nomenclature is one of the great titles to that glory which has been awarded to its immortal author. In the outline of the Linnæan system it has been found possible to describe all plants discovered since his time—an irrefragable proof of the great merits of this artificial classification of species." But although the new mode adopted by Linnæus did much to simplify the science of botany, there were defects in it which Linnæus himself soon detected by the force of his superior genius, but which even he himself was unable to rectify entirely.

In 1731, when the Academy of Sciences resolved to send a traveller to make discoveries in Lapland, Celsius recommended young Linnæus, who set out on horseback, and proceeded along the shores of the Gulf of Bothnia, till he reached the dreary district of Umea Lapmark. Through this province, so soon as the snow melted, he began his wanderings on foot, noting everything, the trees, herbs, animals, mountains, the dress and habits of the people, and sleeping wherever night found him, usually in the wretched cot of a Laplander. He next crossed the Norwegian Alps, a dreary journey, yet every mile of the way was full of allurements for the enthusiastic naturalist; but he was sinking with hardship, fatigue, and hunger, when on the 11th of August he reached Lulea in Sweden. He now visited Finland, Vasa, Abo, and other places, everywhere collecting plants and making notes; till, after travelling on foot and by horse more than 800 German leagues, he returned to Upsala in October, 1732, clad in a *Lapmud* of reindeer skin.

Ambitious to shine in the science he professed, and to secure the means of decent support, in the following year he began to lecture in public on botany, chemistry, and mineralogy, though he had not the right to do so, being without a degree. Information to this effect was lodged against him by a jealous rival, named Dr. Nicholas Rosen. He was forbidden to lecture, and thus deprived of all means for supporting himself. Full of rage, he lay in wait for Rosen, and as the latter left the Senate, he rushed upon him sword in hand, and would infallibly have run him through the body, had not the bystanders interfered. Rosen appealed now to higher authorities; Linnæus was threatened with proscription; yet for a time he still wandered about the streets, seeking for an opportunity of fighting Rosen, and killing him if he could; but after a time Linnæus also became a professor, and then his animosity to Rosen died away.

After another floral expedition through Dalecarlia, he began to lecture at Fahlun, where he fell in love with a beautiful girl named Sarah Moræus, daughter of a physician. He had a baron for his rival; but she preferred the young student, so did her father, who consented to their marriage, after a three years' engagement, and provided that Linnæus took his degree at some university. Here poverty was again a bar; but luckily at this juncture, a pension of sixty dollars yearly was assigned him by the University of Upsala; Sarah gave him one hundred dollars saved from her pocket-money, he left his native country to graduate in Holland, and took his degree at Harderwyk in Guelderland.

From thence he went to Leyden, where he found friends in the persons of Van Royen, the professor of botany; Lieberkuhn of Berlin, "besides Isaac Lawson, a Scotsman, whose loss (says Stoever), like that of the latter, the sciences had too early to mourn," Boerhaave, and Gronovius. At Amsterdam, in 1736, he published his "Fundamenta Botanica," in which the science of botany was reduced to 365 aphorisms. In 1751, the same work appeared under the title of "Philosophia Botanica." In his "Bibliotheca Botanica" he gave a system of botanical

researches divided into sixteen classes, extracted from upwards of a thousand books. In 1736 he was in London, with an introduction from Boerhaave to Sir Hans Sloane, the future founder of the British Museum. "He who shall see you both together," wrote old Boerhaave, "shall see two men, whose like will scarcely ever be found in the world." Sir Hans was displeased by this, and had no desire to see the old system of botanical science overturned by this new one, the sexes of plants and so forth. The chief object of the journey of Linnæus was to see the Botanical Garden at Chelsea, then kept by Philip Miller, F.R.S., who died in his eightieth year in 1771, and who, after some opposition to the new theory, finally arranged the garden on the Linnæan system. From London he went to Oxford, where the chief botanist then was Dillenius, a Hessian, who died in 1747. They conversed in Latin, as Linnæus was ignorant of English; Dillenius, whose age added to the pride of experience, utterly scouted the new system, though he highly esteemed the contriver of it.

After his return from England, the "Genera Plantarum" of Linnæus appeared at Leyden, illustrating the character of 8,000 plants. The same year a supplement to it with 60 more came out. Other brilliant works and translations of them followed; but still the great naturalist was in poverty, and the winter of 1738 found him in Stockholm, and for the sake of his daily bread he endeavoured, by the advice of his intended father-in-law, to practise medicine, but could nowhere find patients. However, on obtaining from the King the diploma of Physician to the Swedish Navy and Royal Botanist, the old doctor could no longer withhold his consent, and on the 26th of June, 1739, he married Sarah Moræus.

In 1741, to his joy, he received an appointment at Upsala. There he was to be professor of anatomy, while his old enemy Rosen was to teach botany; but the following year saw their chairs exchanged by order of the chancellor of the university. In 1745 he had the pleasure to see attached to it a botanical garden arranged under his own care, and on his own system. To profit by his lectures, students came from every country in Europe, and even from America; and during the Seven Years' War they numbered about 1,500. The Academy of Stockholm owes its existence partly to the zeal of Linnæus. He became member of the Academy of Montpellier, of the Society of Toulouse, of the Royal Academy of Berlin; at the instance of Tessin, he obtained the title of Archiater, or Dean to the College of Physicians, in 1747 and in the following year, he lost by death his father, who in his youth had resolved to make him a cobbler.

Under his auspices the royal museums were established in Sweden. In 1754 he discovered that plants were subject to a regular sleep at night like animals; and in order to surprise Nature in her wonders, he was wont to perambulate the garden and the hothouses, lantern in hand, that he might see the vegetable world in its dormant state, and there was scarcely any country in the world which he did not lay under contribution for his collections.

From the King of Sweden he received the order of the Polar Star, together with a diploma of hereditary nobility; and in 1754 he published proposals for cultivating and rendering profitable the wild and waste Alps of Lapland.

In 1772 he gave a fine proof of the vigour of his genius when, on resigning the rectorship of the university, he made a touching oration on "the Delights of Nature;" this was delivered in Latin, but was afterwards translated into Swedish; but two years later, when Lieut.-Colonel Dahlberg brought from Surinam eighty-six specimens of curious plants, Linnæus returned with ardour to his studies, and to the task of cataloguing them.

While lecturing in the Botanical Garden in May, 1774, he had a stroke of apoplexy, and was long insensible. He recovered, but a palsy affected his tongue, and at times he wrote in plaintive words in his diary:—"Linnæus limps, can hardly walk, speaks unintelligibly, and is scarcely able to write."

CHARLES VON LINNÉ OR LINNÆUS.

In the winter of 1776 his condition became more deplorable. Another stroke of apoplexy deprived him of power in his right side. Still he lingered, though his intellectual faculties were as much shattered as his frame, and his life became an intolerable burden, till his illness reached a climax of the most excruciating torture, occasioned by fever and stone. On the 10th of January, 1778, he fell into a gentle sleep, and never woke again.

He was interred in the ancient Cathedral of Upsala, where his remains lie beneath the organ, and in a side chapel in the north aisle is a fine mural tablet of red porphyry, with a bronze medallion portrait of him by Sergell. The inscription beneath denotes that this monument was erected to his memory by his friends and students in 1798, just twenty years after his death.

To the poor and needy foreign students who came to Upsala, remembering the hard days of his own youth, he left the whole of the perquisites which they must otherwise have paid him for lectures. One of the most distinguished attributes of Linnæus was his profound admiration for the divinity of God. In this he resembled Newton, Euler, and Locke. Like the last-named, he kept a diary, in which he recorded the principal events of his life. Besides this, he had began to write, in 1733, a little work, for his own warning, entitled "Nemesis Divina." Over the door of the hall in which he lectured were inscribed by his order the words, "Innocui vivite! Numen adest!" (Live guiltless! God observes you!)

His passions were strong and violent, as we have seen in his quarrel with Rosen; but his heart was open to every impression of joy and tenderness; and he loved jocularity, conviviality, and good living. His son, the younger Linnæus, who succeeded him as Professor at Upsala, was certainly not endowed with the same brilliant mental faculties; but the training he had undergone, and the ample notes and MSS. left by his father, enabled him to maintain with honour the post and the name that he inherited.

FISH CULTURE.—XI.

By Greville Fennell.

OYSTER CULTURE AT THE ÎLE D'OLÉRON, ST. BRIEUX, ARCACHON, AURAY, ETC.—PARCS AND COLLECTORS AT THE ÎLE DE RÉ.

At the Île d'Oléron, fifteen miles from the Île de Ré, slabs of stone from one foot to two feet high, by half a foot broad, are placed on the shore to collect the spat which is drifted to them from the natural beds. Unlike the process at Ré, no parent or breeding oysters are placed near the collectors, the spat being altogether derived from the natural oyster-grounds in deep water. From the fact that in no instance, so far as the Commissioners ascertained, have either foreshore cultivation or enclosed breeding ponds proved successful at any considerable distance from natural banks, or where such formerly existed, it would seem that their existence forms an important desideratum in successful culture. Instances are mentioned in the Report where, under supposed favourable conditions, cultivation has proved abortive, and where no apparent reason could be given beyond the fact that no oysters existed in the adjoining sea, or had ever been known to exist. It is reasonable to suppose that where oysters are absent naturally, and have always been so, some important conditions necessary for their development must be wanting in the water, soil, or temperature, etc.; and this would probably also militate against artificial culture. Considering the numerous oyster-banks which have existed, and still exist, the vast amount of spat annually voided, and the great distances to which it is carried by tides and currents, it is difficult to suppose that there is a square yard of our coasts that has not been visited by spawn; and it would therefore appear that in those places where oysters are not found, Nature protests, as it were, against them. In some places oysters are subject to exposure of more or less duration. In most parts of Ireland this would be attended with considerable risk from frost in winter, unless provision was made for having them submerged, as is the general practice in England.

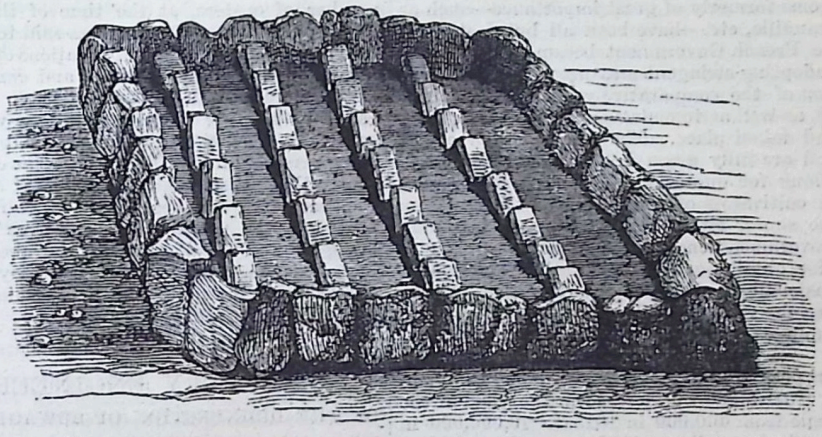


Fig. 24.—DIAGRAM SHOWING MODE OF CONSTRUCTING OYSTER PARCS AT THE ÎLE DE RÉ.

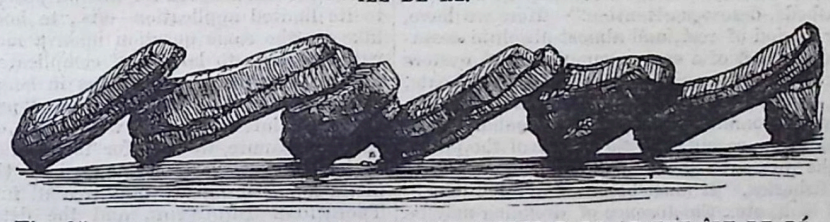


Fig. 25.—COLLECTOR OF ROUGH STONES IN OYSTER PARC AT THE ÎLE DE RÉ.

Although the cultivation is much less remunerative than it was formerly in France, still even in the depressed condition before the late war it paid better than any other industry pursued by the same class for the labour and capital expended upon it: it also possesses the advantage of interfering but little with other occupations, as the attention required to be bestowed on oysters could be given at times when labourers engaged in agriculture would be at leisure. The most encouraging instances of successful cultivation in France are to be found at L'Orient and Auray. At the former M. Charles has obtained remuneration for his capital, and at the latter M. Le Rouse has found as many as 300 oysters on one tile, and expects to profit at the rate of 20,000 francs per year. On the same river La Trinité, at Carnac, there are five other large proprietors; and seventy poor peasants, who have received assistance from the Government, have also commenced operations. All these rivers have a bottom of clay similar to that of the Essex rivers and other localities where oysters are most productive. At the Parc du Forêt, three leagues from Concarneau, the Government layings have proved successful.

The history of the origin of the Government enterprises at St. Brieux and Arcachon is of interest. In 1858, owing to the great scarcity of oysters which had prevailed for some time, M. Coste, a most distinguished member of the Institute of France, who had for some years devoted himself to the study and promotion of pisciculture, turned his attention, with most excellent results, to the promotion of oyster cultivation. By command of the Emperor, he entered into an inquiry on the subject, visited what may be called the parent source of oyster culture—Lake Fusaro, in Italy—and commenced operations in France. The result of his researches and efforts is to be found in his justly-celebrated work addressed to the Emperor, which should be read by all who desire to be conversant with the subject. It is much to be regretted that but a very brief notice of what that eminent man accomplished can be here given. One of his first undertakings was carried out at St. Brieux. This consisted in placing parent oysters, at certain distances, on the bottom of the bay, over an area of forty miles, and fascines or bundles of twigs were sunk, attached to large stones. The result exceeded all expectations, as many as 30,000 oysters being, in some instances, attached to the fascines—nearly all were plentifully covered.

Unfortunately, however, this most promising experiment was frustrated by severe storms, which covered the bottom of the bay with sand, so as completely to bury the fascines. M. Coste's next operation was at Arcachon, on the Bay of Biscay—a land-locked basin equal to about 30,000 English acres. Many years ago a very important oyster fishery had existed there, yielding annually nearly 80,000,000 oysters, valued at £10,000. As alleged, the fishery had become nearly destroyed from over-dredging. Under M. Coste's directions, in 1859, two Imperial parcs—Grand Ces and Crastorbe—were constructed. The first collectors used were wood, to which shells, etc., were attached by a resinous cement: these decayed rapidly, and were replaced by tiles, shells, and stone collectors. The first two years the proceeds were very considerable: subsequently there was a great falling off, but 1869 appears to have produced a very large crop. During six years the quantity removed from the Imperial parc was nearly sixteen millions of oysters; this was independent of the parcs of private proprietors, many of them concessions or allotments by Government, varying from one to eight acres.

A long, grass-like weed (*Zostera marina*), which grows in great quantities on the beds, proves very useful in protecting the oysters at low tide from the heat of the sun. Besides the area under cultivation, there are several natural beds in different parts of the basin, all subject to the Government regulations. The great bulk of the oysters bred at Arcachon are sent to Marennes, on the banks of the rivers Seudre and Tremblade, where the green tint so much esteemed in France is imparted to the beard of the oyster; but against which so unjust a prejudice exists in England as regards the Essex oysters, most of which are in consequence sent to France—the cause of the greenness being probably the same in both instances—the

presence of diatomaceæ, and not, as at Falmouth, owing to the presence of copper. Oysters impregnated with copper are always green in the body, whilst those of Marennes and Essex are green only in the beard or "fin."

The claires of Marennes furnish about fifty millions of green oysters per annum, and these are sold at very remunerative prices. (Bertram's "Harvest of the Sea.") The time required for fattening depends altogether on locality. At Marennes an oyster grows fat more rapidly than in the claires of the Île de Ré.

The only instance of importance of enclosed or tank cultivation in France which was visited by Mr. Francis Francis and his coadjutors was that of Madame Felix, at Regneville. Her experiments proved most successful. The enclosure is about ten acres in extent. In this 11,000 oysters were placed, and 11,000 tiles. The first year, 1864, the tiles were covered with spat, some of them having as many as 103 oysters, and the least of them about 20.

With respect to the natural oyster-beds of France, many of them became so denuded of oysters down to 1850 as to be hardly worth fishing; and some formerly of great importance—such as those of Cancale, Granville, etc.—have been all but destroyed. It was then that the French Government became alive to the urgent necessity of adopting stringent measures to prevent the threatened destruction of the comparatively few that remained on the natural banks, as well as to endeavour to replenish them where exhaustion had taken place. The laws for this object are very effective, and are fully given in the Report of 1870, but are much too long for quotation. Undoubtedly benefits accrued to the small cultivators of the soil near the sea from these grants of free shore, either for breeding or fattening purposes, and the Government encouraged such enterprises by affording facilities for obtaining stock from the Government reserves, and by occasionally making free grants both of oysters and tiles. Sailors, or the relatives and families of sailors, were allowed certain advantages over other applicants for such concessions.

Upon the causes of decline of production in France, the Commissioners state:—"The wonderful increase in the yield of the natural bed of Cancale from 400,000 in 1815 to 70,000,000 in 1847, and the subsequent equally rapid decrease, is a subject which, as it bears upon the restrictions necessary in our own country for deep sea-beds, deserves attention." Here we have, in the return, a long period of rest, and almost absolute cessation of dredging, and the fact of a vast accumulation of oysters taking place. Then follows the onset of a large fleet of boats, without restrictions, which produces, in a few years, the destruction of the bank. Comment is needless. Similar agreement in the main points is presented by the return of the public beds at Arcachon, the present regulations producing a steady improvement in the fisheries. It must be borne in mind that in certain conditions of soil, etc., the absence of dredging may be an evil instead of a benefit to the ground. Cases of this kind are those forming the subject of a Report by Mr. Cholmondely Pennell to the Board of Trade, in 1868. Mr. Pennell states that the Fish and Oyster Breeding Company have cleared 100 acres of the portion of the Blackwater estuary, and thirteen acres of ebb-dry foreshore. Of the state of this ground when it came into the Company's hands, Mr. Pennell remarks that it was, for all practical purposes, barren of oysters, and the "cultch" covered with mud and overrun with vermin and weeds. Fifty-six hauls of the dredge in 1867, before the Company was established, resulted in nine brood and spat, and nine oysters of larger growth. Recently writing in 1870, Mr. Pennell states that *two* successive gave—first, three brood, and sixty-eight spat; second haul, three brood and seventy-five spat (oysters of larger growth not counted), or an increase of 450 to 1 as compared with 1867. A stock of oysters, to the value of £11,631, had been laid upon the ground in 1868 and 1869.

The Roach River Company have reclaimed thirty acres of similar foreshore, and 270 acres of ordinary ground, and the result is equally satisfactory. In 1864, 150 hauls of the dredge gave a total of 38 oysters of all ages; and in 1869 one haul gave 100 brood and 153 spat, or an increase of brood and spat above 1,000 to 1 as compared with 1864.

That oysters cannot be dredged too much from the muddy rivers of the east coast, is the opinion of the oyster-culturist; while those who have ground in rapid and clear water, depose exactly the opposite—namely, that *rest is all* that exhausted grounds require.

The Commissioners are of opinion that all laws to be beneficial must consist of regulations adapted to the requirements of the locality, and not consist of a series of general rules arbitrarily adopted and enforced in despair of obtaining the truth when evidence so very conflicting is offered.

The foreshores at Auray, already mentioned as a success, run from the bridge to the sea a distance of twelve miles, the shores of the river being a scene of oyster culture such as it is hoped will in a few years be seen on many river-banks both in England and Ireland. The process is described as of the simplest kind. Each concession, duly bounded and marked by a numbered post or stone, contains nothing more complicated than rows of tiles, arranged so as to offer clean under-surfaces for the adhesion of the spat, which rises from the preserved banks in the river. To keep these clean, to remove all oysters of a year's growth, to lay them in claires to develop and grow, is all that is needful, and the result is entirely satisfactory. Upon the length of foreshore named no less than 88 parcs have been constructed. The number of oysters, at the time of the visit of the Commissioners, on some of the tiles was said to be 300.

We give in Figs. 24, 25 illustrations of the simple yet ingenious manner in which rude, cheap, and comparatively effective collectors were placed at the Île de Ré. These stones were procured by blasting the rocks, and they served likewise for the construction of the enclosing walls, both collectors and walls being arranged in parallel lines. The cost of a parc of 30 yards square thus constructed was stated at £12; and the number of such increased very considerably in a few years. It is now admitted by the proprietors themselves that the mud and dirt being allowed to collect upon and about these stones, and the improvidence of selling the parent oyster, and thus removing the source of the spat, were the combined causes of the present depopulated condition of the parcs.

SANITARY ENGINEERING.—XXV.

ON THE DISINFECTION OF SEWAGE ON A LARGE SCALE.

In a previous paper (No. XXI.) we have explained the *rationale* of one process adopted for this purpose, but only with reference to its limited application—viz., to house drainage. We now take up the same question upon a more extended scale—*i.e.*, with reference to large and complicated systems of sewerage, measuring perhaps many miles in length, and extending over many acres of ground. With the "products" of the sewage when "disinfected," and with their comparative commercial value as manure, we have for the moment nothing to do. The systems of sewage irrigation, where the matter is dealt with in its liquid form, are ably treated in other sections of The Technical Educator, and the details of one particular system, the A B C as it is called, have been explained at some length. Our present purpose is to describe the results of some of the most recent experiments upon a large scale, describing the various methods adopted, and giving the general result, but leaving the subject at the point of dealing with the sewage when disinfected, its commercial value, etc., which are treated by other authors under other headings. We commence by some extracts from a joint report by Dr. Letheby, the Medical Officer of Health, and W. Haywood, Esq., the Engineer to the Commissioners of Sewers, published in the year 1862, "Upon the Results of the Experiment applying Charcoal to the Sewer Ventilators." We quote from the report:—

"The district experimented upon is in the eastern portion of the City of London. It includes a space bounded by Bishopsgate Street on the west, from Cornhill to Widegate Street, by Middlesex Street and Somerset Street on the east, to the City boundary and by the Minories, and then by Leadenhall Street to Cornhill on the south—the whole of the main thoroughfares above-named being included in the area. It comprises a space of about 59 acres, with about 1,700 houses, and about 14,000 inhabitants.

"This district was selected for various reasons:—(1) Because the sewers have but a slight fall, and the currents in them are sluggish; (2) the area is densely populated, and has more than an average population of poor resident in it; (3) the thoroughfares are mostly narrow, and are therefore disagreeably affected

by the sewer gases from the ventilators; (4) the district afforded good means of isolation from other sewers.

"The total length of sewers in the district is 25,587 feet, of which 2,081 feet are pipes, and the remainder constructed of brick, varying from 3 feet high by 2 feet wide, to 5 feet high by 3 feet wide, internal dimensions.

"Wood charcoal was employed, broken into pieces about the size of a filbert. It was packed closely, but without compression, upon trays specially arranged for the purpose.

"The first air-filter ever put into action in the City was in Philpot Lane in 1859."

The report continues by saying that the deodorising power of the charcoal has been proved to be complete, and that it is patent to actual observation that the "odour of the sewer gases is not perceptible when they have traversed the charcoal."

But here we have to note one special point: the efficiency of the use of charcoal, and the length of time during which it may be safely employed, depend to a great extent upon the absence of damp. In some cases experimented upon twenty months have been allowed to elapse before removing the charcoal, and in others it has been changed at the end of a month. Local circumstances, and the completeness or otherwise of the mechanical appliances for its use, must to a great extent form the guide in practice upon this point.

The analysis of the charcoal when removed shows clearly an extensive absorption of organic matter of various descriptions; but attempts to trace the various constituents to their original source have hitherto met with very partial success.

The second branch of the inquiry has reference to the effect of the experiment upon the quantity of sewer gas admitted into houses during its continuance; but no detrimental results could be identified, and the report proceeds to recommend "charcoal respirators for workmen employed in sewers where any accumulation of noxious gases are to be apprehended." The question of cost was also reported on in full detail, which we will spare our readers, as having recorded the successful results of the experiment we may fairly pass on without further delay to other branches of the inquiry.

Having thus dealt with the disinfection of sewage gases, we now take up the question of the disinfection of sewage itself, and commence by quoting a letter conveying the suggestions and experience of H.R.H. the late Prince Consort, dated April 12, 1850.

"Leaving it to more competent judges to decide whether the sewage should be dealt with as liquid manure or solidified, upon which point His Royal Highness wishes to give no opinion himself, he has confined his attention to the latter mode of application from two causes:—

"(1) That in this shape it could be more easily transported; and (2) could be thus obtained at the least possible expense.

"The plan which His Royal Highness proposes is simply this: to form a tank with a perforated false bottom upon which a filtering medium should be laid, and to admit the sewage into the tank below the false bottom, when according to the principle of water finding its own level, the sewage will rise through the filters, and will run into the drain—if the filtering medium has been of sufficient thickness and of a proper nature—as clear as spring water.

"This medium will then have absorbed all extraneous matter, and consequently become the richest manure, which when the further supply of sewage matter is stopped, can be taken out by a common labourer with a shovel, and carted or shipped wherever desired. His Royal Highness tried the experiment on a small scale with apparent success. The medium which His Royal Highness has used is charcoal, gypsum, and burnt clay, substances in themselves highly useful as manures."

The process thus clearly foreshadowed has been adopted on a scale sufficient to test its efficiency at a large workhouse at Stoke-upon-Trent, containing about 650 inmates. The water-supply is abundant; there are water-closets and urinals, piggeries, stables, baths, etc.; and all the liquid refuse, with the rain-water of the premises, is conducted to one outfall. Previously, the whole of this sewage, about 10,000 gallons, was received into cesspools, the overflow being into the canal, which, however, produced such a nuisance, that as a consequence of certain legal proceedings, the process we are about to describe was adopted.

The sewage is first received into a depositing tank, where the heavier matter is allowed to subside, and then passes through a rough filter of coarse cinders and charcoal into a second tank, two-thirds filled with some filtering material, after leaving which it passes into a chamber in which is placed a cage filled with charcoal, which can be raised, renewed, and replaced when required. At this point the suspended matter is for the most part removed, and the sewage is then conducted through a second series of smaller filters, three in number, filled with finer charcoal and cinders, and the clear effluent water is allowed to escape into the drain. The various tanks are periodically emptied, and their contents thrown into the first tank, which is cleared out once in eight months, its contents mixed with ashes to secure dryness, and carted away to a manure factory at Newcastle-under-Lyme. The Birmingham Committee of Inquiry, who visited the works, report that they could detect no offensive odour.

It may perhaps be mentioned that the filters, though sufficient for 10,000 gallons daily, are unequal to meeting emergencies in times of heavy rainfall, when perhaps double the quantity, 20,000 gallons, have to be dealt with.

But this difficulty may be met either by enlarging the filters, or providing a reservoir large enough to contain the sewage arising from any possible flood, which might subsequently be passed through the filter by slow degrees.

At Bradford in Yorkshire works are now in progress, and nearly completed, by the Peat Engineering and Sewage Filtration Company, for dealing with the entire sewage of the town, about 5,000,000 gallons, upon this principle. The sewage will be conducted through several rows of filtering beds 700 feet long and 4 feet wide, and each particle of sewage will have to pass through 12 feet of charcoal.

The charcoal is manufactured from peat by the company above mentioned, at their works at Red Moss, under their patent, and there is practically no limit to the supply.

The charcoal when fully charged with sewage matter has considerable value as a manure, but this is beyond the scope of our present paper.

The attention of the engineers of the day, in this country and on the Continent, is now turning more in the direction of dealing with sewage in its solid form, and we recently saw some experiments in progress by which, with the convenience of a water-supply, a mechanical arrangement secured the retention of the solid matter, the surplus water being allowed to flow off by regular drainage channels, at the same time a powerful disinfectant was thrown on to the solid matter, which was subsequently removed as already described in our paper on Moule's Earth-closet System. The scheme was intended for a large Continental town, but the details are not sufficiently mature for us to do more than describe the general principle. Suffice it to say that these novel methods of treating sewage in the solid will never probably be desirable or applicable in large mercantile centres, such as London, Liverpool, or Manchester, as the immense additional organisation required would entail vast additional expense, while much of the existing drainage and other work would be rendered unavailable. If in the course of years the process becomes more extensively adopted, it would only be by the discovery of some method by which the product of the disinfected sewage would become sufficiently valuable to defray the cost of collection; but we have no hesitation in saying—and in this opinion we are supported by some of the best authorities of the day—that upon an extended scale this result has never been obtained in this country. We have read many curious particulars as to the way in which, in China, great results are obtained by the direct use of sewage matter for manuring purposes, which show clearly that under certain conditions the results are very remarkable; but the comparative states of their civilisation and our own are so widely different that no conclusion can be drawn from the facts as applicable to ourselves.

We conclude by alluding to one or two schemes for the chemical treatment of sewage, only remarking that hitherto we have no record of commercial and financial success upon a large scale.

One of these processes, as explained by Mr. David Forbes, F.R.S., "consists in treating the sewage with a solution of the native phosphate of alumina dissolved in sulphuric or hydrochloric acid. This solution is in itself a powerful antiseptic and disinfectant, completely arresting further putrefaction, and

depriving the most fetid sewage of its offensive smell; causing at the same time the supernatant water to be clear and colourless, even if tinctorial substances of great intensity be present in the liquid." This is commonly called the phosphate process. Another method employs lime, tar, and calcined chloride of magnesium, with other matters in certain proportions.

TECHNICAL DRAWING.—LXXX.

DRAWING FOR CABINET-MAKERS (*continued*).

FREEHAND DRAWING.

The trade of a cabinet-maker is so dependent upon design, and stands in such close connection with wood-carving and other branches of ornamental art, that it will be almost unnecessary to point out the immense importance of this branch of study. Taste and refinement are called for in every article of furniture, and unless a man is satisfied to be a mere drudge—unless he would chain himself down for the whole of his life to the lowest class of work, and consequently to the lowest scale of wages—he must endeavour to improve his capabilities; he must, by self-culture and labour, fit himself for the great battle for superiority which is now going on between foreign nations and ourselves. The manual skill of our artisans is unquestioned, but they have until recent years wanted the art-culture which has been liberally bestowed on their class in other countries. Opportunities, however, are not now wanting; the noble Schools of Art and Science established throughout the kingdom are open to artisans at a charge easily within their means, and it is to be hoped that, in a few years' time, our English cabinet-makers will be able to assert, and boldly to maintain, that superiority in design and workmanship of which they have shown such great promise in the recent international exhibitions.

An important series of elementary lessons in freehand drawing is given in Lesson XLI. of "Technical Drawing" (Vol. II., page 265). To these and numerous other freehand examples given in the various courses of lessons, the student is referred, and he is urged to work the exercises carefully before attempting the following subjects.

Fig. 617.—This example presents part of the side with feet of a small work-table, which the student is advised to draw to a much larger scale, completing of course the right foot omitted in the figure.

In commencing, draw the ground-line and the central perpendicular, then the horizontal lines for the mouldings which separate the side from the feet.

Now draw the scroll *a* on the left, and balance it by the corresponding curve on the right side; then draw the interior line *b*, but omit for the present the inner lines showing the edging. The drawing should, in fact, at this stage show the work as roughly cut out by the saw, before being handed over to the carver.

Draw the scroll *c*, and the curve *d*, for the outer line of the leg, repeating the same on the opposite side, and complete the general form of the legs by the interior outline *e*, which is to be carried round so as to form the scroll terminating the foot.

Next draw the middle part *f* of the upper portion of the subject, and the scrolls crossing each other in *g* beneath it. Having taken a careful survey of the whole, with the view of correcting the general form and proportion, the inner lines, showing the edging, etc., are to be drawn. Figs. 618 and 619 are sections on *h i* and *j k*, which will serve as guides in this portion of the work. The whole drawing will then be ready for "lining in."

Fig. 620.—This is a pattern for a running scroll, arranged so as to repeat; *a* will therefore join on at *b*, and thus the design may be continued.

It will be seen that, in order to equalise the spaces so as to carry out this arrangement, the whole is divided into squares, and the central flower is placed on the intersection of the diagonals.

Fig. 618.

Fig. 619.

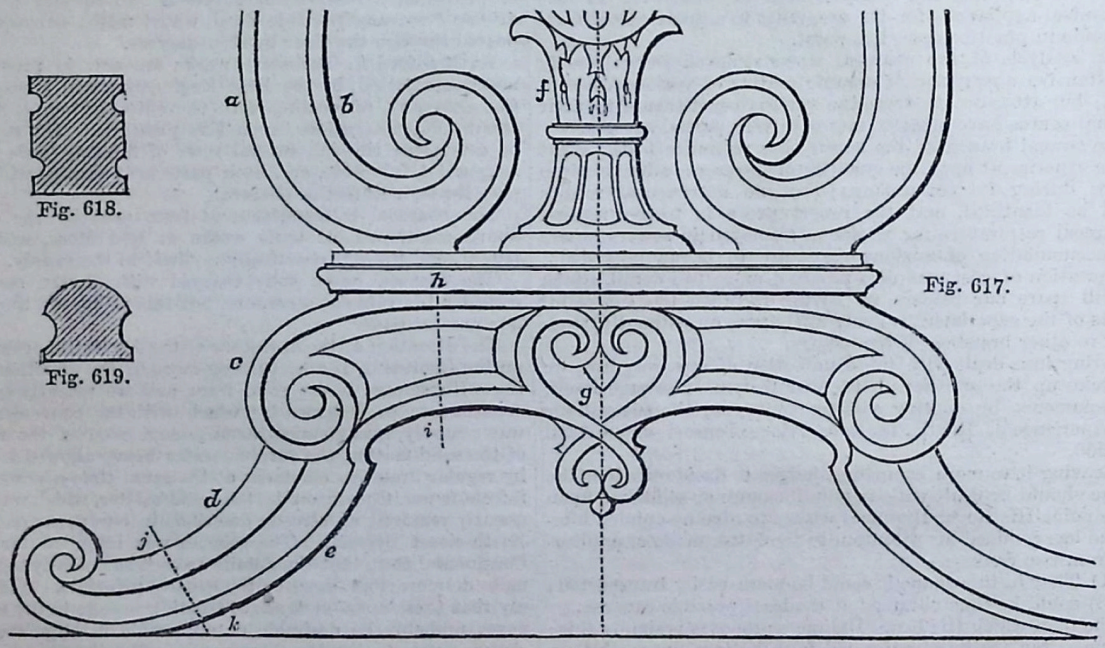


Fig. 617.

In commencing this design, the general form is to be sketched of each scroll rising out of the previous one. At this stage no notice should be taken of the husks or foliage, *c*, *d*, etc., but the scrolls should be sketched as if consisting of the flowing stem only, and the husks should then be drawn outside the original form.

Great care must be exercised to ensure the smooth, spiral character of the curves. There must be no angular breaks, but the eye must be carried onward towards the centre of each scroll, and the husks must appear as *additions*, but not as *excrescences*. In order to test the correctness of the forms, turn the sketch upside down, place it vertically, or in any other direction, and if the design has been correctly sketched, the scrolls should be equally perfect in whatever position they may be viewed. This should be repeatedly done during the progress of the work, so that any part which may be too full or too flat may be improved before the husks, flowers, foliage, or other details are added.

Fig. 621.—The design shown in this example is a scroll such as might be used in ornamenting a console, etc. We shall give the description here with such hints and instruction as may be necessary to the learner, but the design itself will be found in our next lesson. (See Fig. 621, page 125.)

Draw the right angle in which the figure is to be contained, then sketch freely the spiral commencing at A, and continuing to B, following the direction of the stem only, regardless at the present stage of the foliage by which some portions of it are covered.

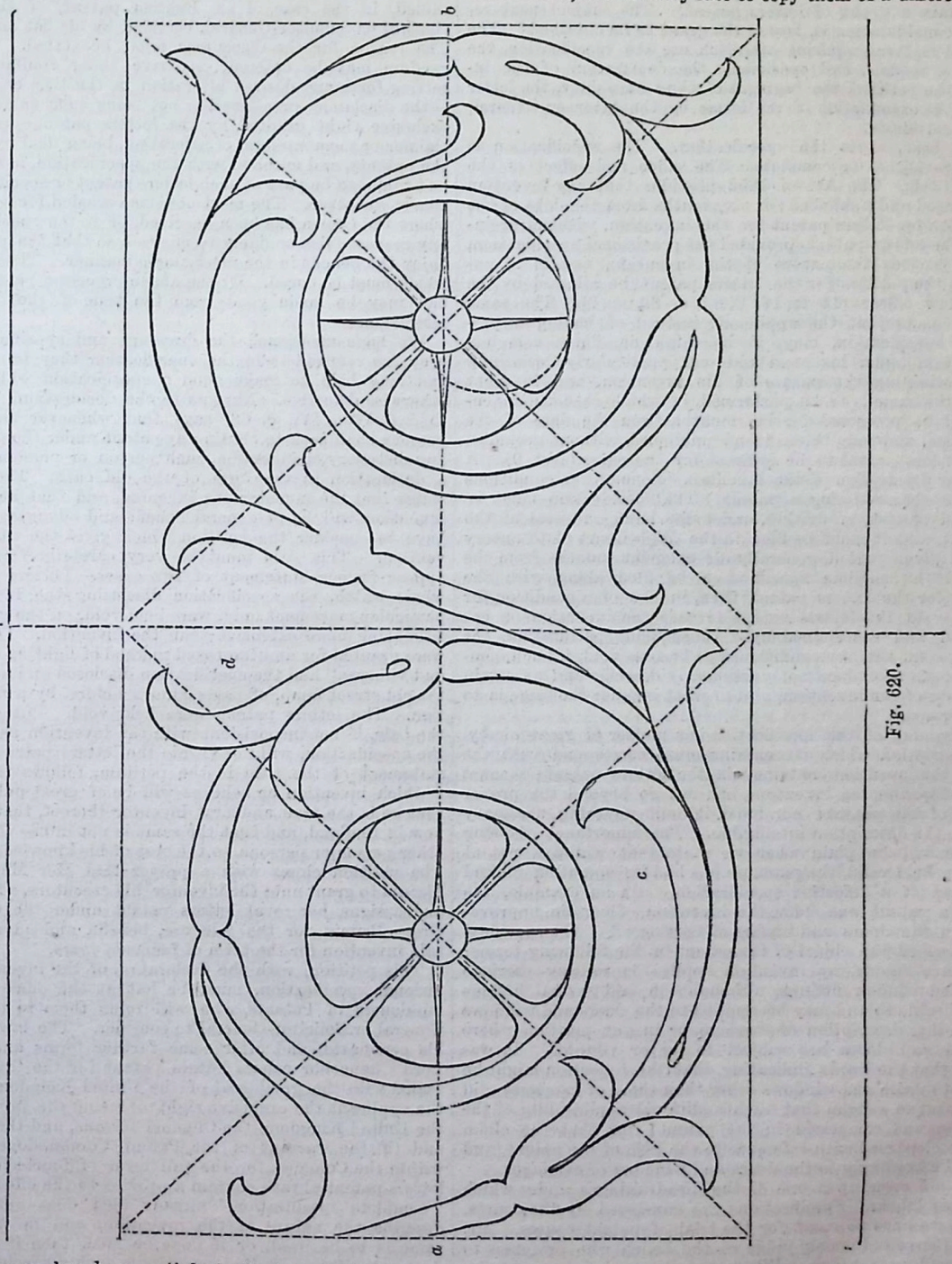


Fig. 620.

When this curve has been satisfactorily traced, draw the corresponding one, commencing at C, and following to D.

The foliage is next to be drawn, and in doing this the general form must be sketched first—the shape, as it were, of the block out of which it would be carved. This is shown in one portion, commencing at E. Thus from E draw the form extending to F, and thence to G. This will give the one lobe. Next proceed to H, and thence to I. In this way the whole of the foliage is to be sketched in, and the bud and minor parts are then to be added. The separate portions of the leaves are next to be drawn within the forms already traced. The whole is then to be carefully corrected and lined in.

The student is urged to vary the studies herein given, to reverse them, and in every case to copy them of a different size. Natural flowers and foliage afford the most excellent subjects for study, and thus the student who wishes to work need never stand still for want of examples.

We have said that the design to which the description just given applies is one which might be used in ornamenting a console or bracket. It will be a useful exercise for the student to attempt to make such a drawing as he may imagine to answer to our description, and then compare it with our design in Fig. 621 (page 125).

PATENTS AND PATENT LAW.—III.

By A Barrister.

HOW TO OBTAIN A PATENT AND HOW TO EXTEND IT.

We have seen what may be the subject of a patent, and who may obtain a grant of letters patent. The subject next requiring consideration is, how is the grant to be obtained? The principal matters requiring attention are the specification, the drawings, models, and specimens, the declaration of the inventor, the petition, the payment of the stamp duty, the letter patent, the examination of the letter by the Attorney-General, and his certificate.

First, then, as to the specification. The specification is either provisional or complete. The office and effect of the former is this. The Act of 1852 provides that any invention may be used and published for six months from the date of the application for letters patent for the invention, without prejudice to the letters patent, provided the provisional specification, which describes the nature of the invention, and is to accompany the petition for the letters patent, be allowed by the proper law officer (15 & 16 Vict., c. 83, s. 9). The same statute enacts that the applicant, instead of having a provisional specification, may, if he think fit, file a complete specification under his hand and seal, particularly describing and ascertaining the nature of his invention, and in what manner the same is to be performed, in which case the invention will be protected for six months from the date of the application, and may be used and published without prejudice to any letters patent to be granted for the same (sect. 9). A particular description of the invention is one of the conditions which we observed clog a patent. The specification must be clear and precise, in writing, under the hand and seal of the applicant, and it must be filed in the High Court of Chancery within a given period, generally six calendar months from the date. If a complete specification be filed along with the petition for the letters patent, then, in lieu of a condition for making void the letters patent in case the invention be not described and ascertained by a subsequent specification, the letters patent shall be conditioned to become void, if such complete specification does not particularly describe and ascertain the nature of the invention, and in what manner the same is to be performed.

The framing of the specification is a matter of great nicety. The description which it contains must correspond with the title of the invention contained in the letters patent; it must clearly describe the invention, but not go beyond the proper subject of the patent; nor must it omit anything necessary to make the description intelligible. The importance of being accurate will be plain when we state that whilst a patent has been held valid, the patentee has had its operation limited by reason of a defective specification. As an example, the title of a patent was "for the invention of certain improvements in the doors and sashes of carriages." The specification described the object of the patent in the following terms:—"I have shown my invention applies to railway carriage doors and window fittings, although the said several fittings are applicable to and may be applied to the doors and windows of any other description of carriage, or in any position where windows and doors are subject to jar or vibrate." It was decided that the words indicating that the invention might be applied to doors and windows other than those of carriages, did not amount to a claim that such additional applicability of the invention was comprised in the patent; for that the claim must be construed with reference to the title of the patent, and confined accordingly to the doors and windows of carriages.

Here we come upon one of the disadvantages under which patentees labour. Specifications are construed by the courts, and yet we have no court for the trial of patent causes. Mr. Justice Grove is the only judge on the bench who professes to understand patent law. Where novelty or infringement depends merely on the construction of the specification, it is a pure question of law for the judges; but where the consideration arises how far one machine, or a material part of one, imitates or resembles another in that which is the alleged invention, it generally becomes a mixed question of law and fact which must be left to the jury. The only aid which can be given to the court in construing a specification, is that obtainable by means of evidence admissible to explain terms of art or technical expressions known only to particular trades. There is a means, however, by which a grantee or assignee of any letters patent may abandon portions of the title or specification, and this process is called a disclaimer. This disclaimer must be entered with the clerk of the patents, after leave obtained, in the case of an English patent, of the Attorney-General or Solicitor-General, certified by his fiat and signature. The reason for the disclaimer must be stated. Or a memorandum may be entered, on leave being similarly obtained, setting forth any desired alteration in the title or specification—the disclaimer or alteration not being such as to extend the exclusive right granted by the letters patent—and such disclaimer or memorandum of alteration, being filed by the clerk of the patents, and enrolled with the specification, is to be deemed and taken to be part of such letters patent or specification in all courts whatever. The most obvious occasion for a disclaimer is where the Crown has been deceived, or if the specification is in any respect false or likely to mislead, so that the public cannot enjoy the benefit in the most ample manner. These are defects which must be cured. By the above process a patent originally bad may be made good from the time of the disclaimer or alteration.

We have mentioned the drawings and specimens. Where they are referred to in the specification they form part of it, and may help to make good a specification which would be otherwise defective. Next as to the declaration. The statute (5 & 6 Wm. IV., c. 62) says that whenever any person or persons shall seek to obtain any patent under the great seal for any discovery or invention, such person or persons shall make a declaration in the form of the old oath. The declaration states that the inventor has invented, and that he believes his invention will be of general benefit and advantage. Next we have to consider the petition which gives the title of the invention. This title must be very carefully framed, as will appear from a statement of two cases. Letters patent for a whole watch, the specification disclosing the invention of a particular movement only, were held void, on the ground of the title being more extensive than the invention. Letters patent were granted for an "improved method of lighting cities, towns, and villages," and the specification disclosed an improvement of the old street lamp, of parts known before, by a new combination. The letters patent were held void. But generality in the title, if not inconsistent with the invention as described in the specification, will not vitiate the letters patent. After the statement of the title in the petition, follows the averment, "which invention he believes will be of great public utility;" that he is the true and first inventor thereof, that the same is new in England, and that the same is not in use therein by any other person or persons, to the best of his knowledge and belief. The petition closes with a prayer that Her Majesty will be pleased to grant unto the inventor, his executors, administrators, and assigns, her royal letters patent under the great seal of Great Britain, for the sole use, benefit, and advantage of his said invention for the term of fourteen years.

This petition, with the declaration of the inventor, and provisional specification, must be left at the office of the Commissioners of Patents, who will refer them to the Attorney-General or Solicitor-General to consider. The law officer gives his certificate, and after some further forms and delays, the Lord Chancellor causes letters patent for the invention to be sealed with the great seal of the United Kingdom, granting to the applicant the exclusive right of using the invention within the United Kingdom, the Channel Islands, and the Isle of Man, and (if the warrant of the Patent Commissioners so direct) within the Colonies, for the full term of fourteen years. The letters patent always contain a proviso to the effect, that if the "complete specification" already filed does not particularly describe the nature of the invention, and in what way the same is to be used, or if none be filed, then if the applicant does not within a limited period file such a specification in the Court of Chancery, the grant in the letters patent contained shall be void.

A difficulty may arise in the course of these proceedings by the opposition of those interested in objecting to the grant of the letters patent. Any such persons are at liberty within a certain period to lodge particulars in writing of their objections. Similarly, objections may be made to applications to the Privy Council to prolong patents, a matter to which we will now

shortly advert, as being in effect a part of the grant. What the requirements of the Privy Council are, may best be explained by reference to the case of Hill's patent, a prolongation of which was opposed by a host of opponents. It was there said that in determining whether to recommend a prolongation of a patent or not, even where the claim to the first discovery and the beneficial nature of that discovery are both conceded, it will be still proper to consider both the degree of merit as inventor, and the amount of the benefit to the public flowing directly from the invention. These general observations, going really to the root of the principle upon which patents are granted, then follow:—A monopoly limited to a certain time is properly the reward which the law assigns to the patentee for the invention and disclosure to the public of his mode of proceeding. Whether that term shall be extended, in effect whether a second patent shall be granted for the same consideration, and the enjoyment by the public of its vested right be postponed, is to depend on the exercise of a discretion, judicial indeed, yet to be influenced by every such circumstance as would properly weigh on a sensible and considerate person in determining whether an extraordinary privilege not of strict right, but rather of equitable reward, should be conferred.

The prolongation of the patent in Hill's case—for an improved mode of compressing peat for making fuel or gas, and of manufacturing gas, or of obtaining certain substances applicable for purifying the same—was opposed on the several grounds of want of novelty, want of utility, and of the patentee having had sufficient remuneration. The Judicial Committee refused to entertain the objections going to the root of the validity of the patent—viz., want of novelty and want of utility—but proceeded to the question of want of merit in the inventor. The crucial test applied by this court was, has the individual patentee, under all the circumstances, received what in equity and good sense may be considered sufficient remuneration? To assist the court, a patentee on applying for a prolongation must furnish accounts, and it may be well that we should take from the judgment in Hill's case a description of the accounts required. "It must be remembered," are the words of the judgment, "that the accounts which a patentee renders in support of such a petition as the present are not such as might be proper between two several claimants on the returns of a mercantile firm, but such as show what profits made by a firm or individual are in a large sense attributable to the possession of the patent right—those which, without the patent, would not have existed at all; not, of course, excluding all just deductions for labour, capital, etc. If, but for the patent, there would have been no manufactory, then the net profits of the manufacturer are in that large sense attributable to the patent. . . . . Their lordships cannot satisfactorily discharge their duty unless they have the whole case before them. They must know the whole remuneration; different considerations may be applicable to different parts of it; but if to any extent the patentee has received his remuneration by the making and selling the patented article, the profits on that sale must be disclosed and taken into account." As to the deductions allowable, a patentee is not entitled to deduct from profits any loss by foolish or imprudent bargains, or hasty compromises of litigation; and where he manufactures his own invention, he is not entitled to deduct two-thirds as manufacturers' profits, and count only the other third as the profit alone attributable to the patent.

The prolongation of patents, we have before remarked, is entirely discretionary, and any reasonable conditions may be imposed. For example, in the case of Mallet's patent relating to the construction of fire-proof structures, licences had been granted by the patentee, and the Privy Council prolonged the term on condition that similar licences were granted to the public on the same terms.

It may be advisable to advert briefly to a case in which a patentee was held to have deprived himself of all right to a prolongation. This was the case of Trotman's patent for improvements in anchors, and in addition to the fact that his accounts were unsatisfactory, the Judicial Committee of the Privy Council considered that he had so dealt with his patent rights as to deprive himself of the power of showing the amount of profit derived from the working of the patent. This was the essential element, as the prolongation was asked for on the ground that the patentee had been insufficiently remunerated. This question of insufficient remuneration being an important one, we will quote the observations of Lord Chelmsford. There was, he pointed out, a peculiarity in this case—viz., the patentee, "instead of becoming himself a manufacturer of his patented anchors, has preferred to grant licences to ironsmiths to manufacture them on their own account, paying him a royalty. In all prior applications for the extension of the term of a patent, the patentee has himself made and sold the patented article, either exclusively or in common with other persons to whom he has granted licences, or he has assigned away his patent altogether, so as to substitute his assignee for himself in all questions respecting his patent rights. In these cases there is obviously no difficulty in ascertaining the profit which has been derived from the patent. It is supposed, however, that the unusual manner of working the patent in this case renders the application of a different principle necessary. This, however, is clearly a misapprehension. The question in all cases of this description is not what the patentee has received, but what has been made, or by proper judgment and application might have been made, by the patent. The petitioner might, if he pleased, have become the manufacturer of his patented anchor. If he had, it would have been necessary to ascertain what part of the profits of the manufacturing business ought to be ascribed to the patent. . . . But the petitioner was unwilling to incur a large expenditure in erecting the proper plant for carrying on the manufacture, and preferred to leave the expense of the new machinery necessary for forging his anchors to the licensees, being content to receive a royalty as his share of the profits of the patent business. Under these circumstances, if his royalty alone were to be regarded, it is evident that we should not arrive at a knowledge of the whole amount realised by the patent, but that the question would be changed from what the patent had produced to what it had yielded to the patentee." And on the general principle of prolongation it was said, "It must always be borne in mind that the extension of the term of a patent is matter of favour, not of right; and that it is essential to the favourable consideration of the patentee's application, that he should distinctly prove how much the public have had to pay, or, in other words, how much has been received on account of the patent. If, therefore, the patentee has dealt with his patent rights in such a manner that, when the time arrives for asking for a renewal of his term, he has put it out of his power to give the requisite evidence upon which his application must to a great extent have been founded, his petition must fail, because it wants the proof which is essential to its success." From this we deduce that a patentee who is his own manufacturer is in the best possible position for obtaining the renewal of his term.

Patents taken out in a foreign country may have an important bearing upon the question of prolonging English patents. The rules under the Act of 1852 seem to be these:—If an English patent is taken out before a foreign patent, the prolongation of the English patent will be granted, although the foreign patent has expired. Where a patent is taken out in a foreign country before a patent for the same invention in the United Kingdom, the latter patent must terminate at the same time as the foreign patent. And where the term of a foreign patent has expired, any grant of letters patent in the United Kingdom made after that period is of no validity. And where the two patents are taken out simultaneously, it would seem that a prolongation of the English patent may be granted.

Lastly, as incidental to obtaining a patent, we may refer to the payments to be made by the patentee. The statute 16 & 17 Vict., c. 5, s. 2, provides for the payment of the stamp duties set out in the schedule at the expiration of three and seven years from the granting of the patent. Unless these payments are made the letters patent will be void, and the powers and privileges thereby granted will cease. It may be interesting to our readers to know what these payments are. The schedule contains the following:—On petition for grant of letters patent, £5; on certificate of record of notice to proceed, £5; on warrant of law officer for letters patent, £5; on the sealing of letters patent, £5; on specification, £5; on the letters patent, or a duplicate thereof, before the expiration of the third year, £50; on the letters patent, or a duplicate thereof, before the expiration of the seventh year, £100. An application for a disclaimer costs £5.

INDIAN RUBBER.—I.

BY GEORGE GLADSTONE, F.C.S.

FIRST INTRODUCTION—SOUTH AMERICAN CAOUTCHOUC—INDIAN CAOUTCHOUC—SIPHONIA ELASTICA—MODE OF COLLECTION—FICUS ELASTICA—URCEOLA ELASTICA—CHEMICAL CONSTITUTION—PHYSICAL PROPERTIES.

It is only since the beginning of the last century that indian-rubber or caoutchouc has been known in this country; and when the first specimens arrived, speculations were rife as to whether it belonged to the vegetable or mineral kingdom. This may seem now to be very absurd; but there were stronger reasons for inferring a mineral origin than perhaps even those who held this view were aware of at the time; this will more particularly appear when we come to speak of its chemical composition. The question as to its vegetable origin was set at rest by a communication to the French Academy in 1736, in which it was stated to be the inspissated juice of a tree which grows in South America.

From that time till 1770 it appears to have been a mere curiosity. In that year it was introduced to the British public for the purpose to which it was long almost exclusively devoted, and from which it has derived its familiar name. In the preface to a book on perspective published in that year, the following singular passage occurs. "Since this work was printed off, I have seen a substance (no name is given to it) excellently adapted to the purpose of wiping from paper the marks of a black-lead pencil. It must, therefore, be of singular use to those who practise drawing. It is sold by Mr. Nairne, mathematical instrument maker, opposite the Royal Exchange. He sells a cubical piece of about half an inch for three shillings, and he says it will last for several years."

Just fifty years after that time experimenters, attracted by its singular and valuable properties, began to turn it to new and more important uses; and in 1823, Mr. Mackintosh, of Glasgow, succeeded in applying a solution of Indian rubber to cloths, by which he made the waterproof article which has since borne his name.

Up to that period the supply of the raw article was almost exclusively limited to the South American, though one identical in its properties was known to be procurable in India, having been discovered by Dr. Roxburgh in Assam about fourteen years previously. Had it not been for the exertions of Dr. Forbes Royle, the East Indian caoutchouc might have remained much longer in obscurity; for when a gentleman up the country sent some to his agents in Calcutta, they simply wrote in reply that "the article being unknown in this market, we are sorry we can give you no idea of its value." This happened in 1828, when it was selling in London for 2s. per lb. By 1840 it had become a regular article of export, and by its competition had considerably reduced the price of the South American caoutchouc. From this time onward the sources of supply have been increasing as new modes of utilising it have arisen; and it is satisfactory to know that with proper care the produce of Indian rubber may be considered practically inexhaustible.

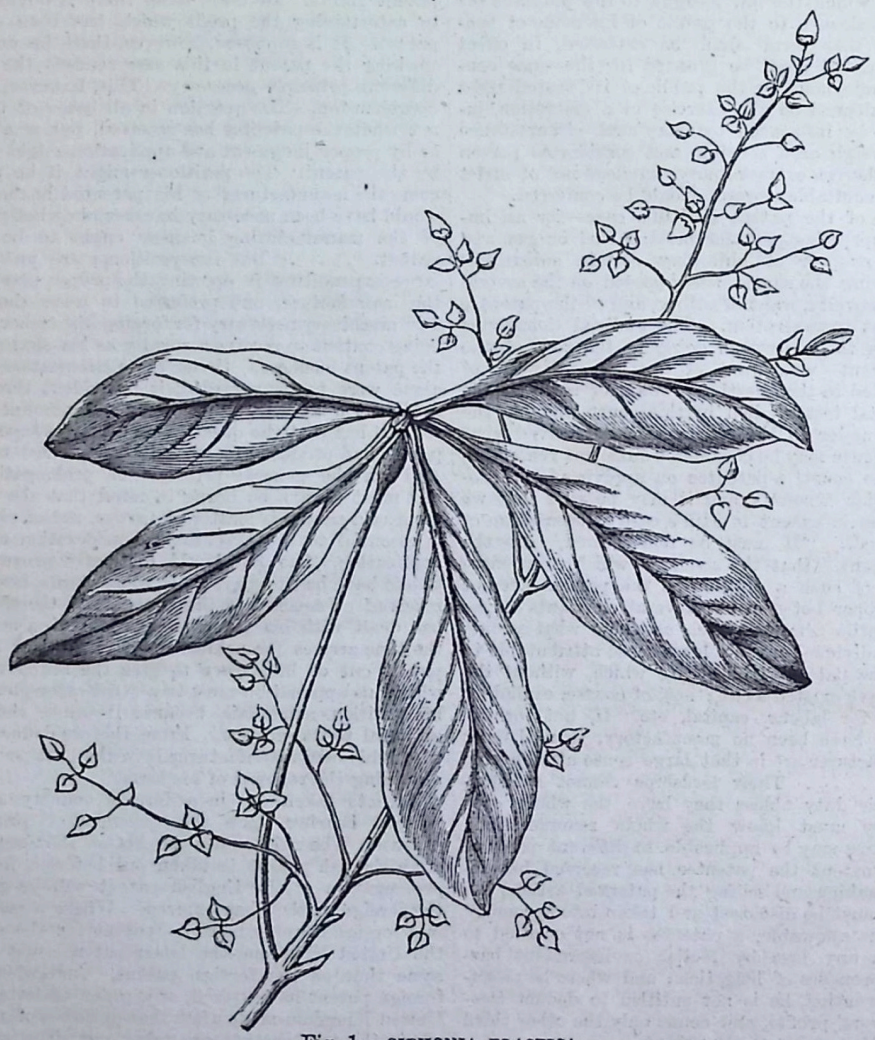


Fig. 1.—SIPHONIA ELASTICA.

It is not a little curious that what is generally known as the Indian rubber tree, young plants of which are grown so largely in London rooms, is not the one which was first discovered, or which even now supplies the great bulk of the raw material. It is the Assam plant; whereas the South American one belongs to an altogether different family.

The Euphorbiaceæ, or family of Spurgeworts, which are common in all the four quarters of the globe, all produce a milky juice, and it is this which in drying yields caoutchouc. *Siphonia elastica* is the tree from which it was originally derived. It grows in the low lands which form the basin of the great river Amazon. It is a true forest tree, growing up to a great height, generally 40 to 50 feet, before throwing off any branches; and sometimes reaching 80 to 100 feet in all. The trunk is usually 2 to 2½ feet in diameter. The crown is spreading and ornamented with a thick and glossy foliage, the character of which may be judged of by the accompanying drawing (Fig. 1). The milk may be collected at any period of the year, but it is considered best to do so in the dry season; and as the trees which have hitherto been tapped are those growing on the islands and in the swamps within the distance of 50 to 100 miles to the east of Para, there is an additional cause for choosing the dry season. This lasts from August to February. The trees, however, are not confined to this limited area; for Mr. Bates, on exploring the Amazon and its tributaries, found plenty of untapped trees in the wilds of the Tapajos, Madeira, Juruá, and Jauarí, as far inland as 1,800 miles from the coast.

The rubber—the original native name for which is *cahuchu*—

is collected in the following manner:—As soon as the dry season has set in, a party of Indians, men and women, proceed into the virgin forest to seek a clump of Siphonia trees, and when they have found a suitable sphere of operations, they cut paths through the wood to it. This is a work of no little difficulty, as, owing to the fertility of the soil and the tropical climate, the undergrowth forms a dense mass, and every step must be gained by the axe. Having effected a clearance, they make an incision in the trunk of each tree, about five or six feet above the ground, just below which they stick rude cups of clay to receive the milk as it flows out. Each morning they make a round of the trees to empty the cups of the milk, usually about a gill in quantity; and when the first incision ceases to yield, a second, and then in like manner a third and a fourth, is made. By this time the tree is exhausted, and it will not recover itself for a couple of years. The milk collected day by day is poured into larger vessels, and then the manufacturing of the rubber commences. For this purpose the natives gather together in heaps a quantity of Urucari or Inaja nuts, which, upon being set on fire, yield a thick oily smoke. Moulds of clay, in the shape of shoes, bottles, etc. etc., are prepared, which are dipped into the milk, and then held over the fire to dry. This is repeated day by day, until the articles have acquired sufficient thickness. The juice itself is yellowish, and of the consistence of thick cream, the dark colour of the manufactured article being due solely to the smoke in which it is dried. In some interior districts, where the nuts are not found, the rubber is sun-dried, and of a very light colour. For some little time after the smoking is finished the surface is rather sticky, and the several pieces would be liable to adhere together if they were allowed to touch; the shoes and other articles are therefore hung over horizontal poles to dry, and the natives usually bring their produce to market suspended in the same manner.

Several other kinds of Siphonia are to be found in tropical Brazil and Guiana, as well as other members of the family of Euphorbiaceæ, which also yield caoutchouc, but not in such quantity as the one above described.

The *Ficus elastica*—commonly known here as the Indian-rubber tree, from the diminutive specimens in rooms and greenhouses—belongs to the large family of Artocarpaceæ, which includes the Banyan, *Ficus Indica*—the largest of known trees—and the Breadfruit, which is the most prolific. The tree is found in great abundance in the forests of Assam and its neighbourhood; it is a true forest tree, of rapid growth, attaining 80 to 100 feet in height, with its branches extending to the distance of 75 feet in all directions from the parent stem. The larger branches throw out roots which descend to the earth, in the same way that the Banyan does. The incisions for the drawing off of the juice are made in the bark around the trunk, beginning at the base, or at the reflex roots, which generally lie exposed. The juice from the roots is found to be richest in caoutchouc. The oldest trees should be selected for the purpose of tapping, and the operation conducted in the cold season, as the juice then contains the largest proportion of solid, and the health of the tree is less affected than it would be were the sap withdrawn during the period of rapid growth. The bleeding may be repeated every fortnight; about 45 lbs. weight being obtained on each occasion. In India the rubber is sun-dried, so that it retains its light colour. The tree is generally to be found in the sheltered nooks of a rocky district; and as the region in which it is indigenous has as yet been only imperfectly explored, there are no precise data for estimating the probable supply from this tree. Sufficient, however, is known to assure an abundance of it for a long time to come. Other sorts of Ficus—the *Indica* and *religiosa*—also yield caoutchouc; and so does the Jack Tree, or *Artocarpus integrifolia;* but these are not usually tapped for the purpose.

Again, in the southern part of the Malay Peninsula, and in the great islands of Sumatra and Java, there is the *Urceola elastica*, belonging to the order Apocynaceæ, which yields the same product in great abundance. This plant, indeed, was the principal source of supply from the East prior to the introduction of that from the *Ficus elastica*. Its importance seems to have been discovered by accident, towards the close of the last century, the circumstance being recorded in the "Asiatic Researches" of 1798. It appears from the narrative, that in clearing a way through the jungle with cutlasses in the island of Penang, the juice which had collected on the blades turned on drying into a substance possessing all the characteristics of Indian rubber. The source of the juice was found to be a vine about as thick as a man's arm, which trailed along the ground for a great distance, sending out rootlets from each joint, and ultimately climbing to the top of the highest trees. Fig. 2 will show the character of its foliage.

Fig. 2.—URCEOLA ELASTICA.

These three plants which have been more particularly described are by far the most important that are yet known. But the families to which they belong are so widely spread, that there is every reason to expect that as the tropical regions both of the Old and New World are more thoroughly explored, many other districts will be added to the list of those which now produce this article. Its production seems to be greatly favoured by heat, as the milky juices of the Euphorbiaceæ which grow in temperate climates contain next to none of the solid matter; and it has been remarked by Humboldt that the proportion of it increases as the region from which they are derived is more essentially tropical.

The quantity of Indian rubber contained in the juice varies greatly, up to about 45 per cent. The rest consists almost exclusively of water, which is artificially expelled in South America, and by exposure to the heat of the sun in India. The

season of the year, the age of the tree, and other circumstances, all have their influence in increasing or decreasing the proportion of caoutchouc in the sap.

Caoutchouc is, in chemical language, a hydrocarbon; that is, a substance consisting of only the two elements, hydrogen and carbon. It would perhaps be more correct, however, to use the plural number, as it does not appear to consist necessarily of one, but rather of two or more hydrocarbons mingled together. The analysis by Faraday of a carefully selected sample gave the respective proportions at 87·2 per cent. of carbon, and 12·8 per cent. of hydrogen, which would indicate a composition of C_4H_7, or a multiple of those numbers. Other experimenters, however, have obtained results rather different from his, which points to the conclusion that it is not a strictly definite substance; and this is confirmed by experiment, for on dissolving it, one portion is often found to be more soluble than another, and the resulting solution cannot all be distilled over at a uniform boiling-point.

Under the microscope there is no evidence in Indian rubber of any structure, either fibrous or cellular, which would serve to identify it as of vegetable origin; and those who formerly declared it to belong to the mineral kingdom might have produced in support of their view an undoubtedly fossil hydrocarbon, also possessed in some measure of elasticity. Now-a-days, too, it is from the bowels of the earth that we derive the raw article from which by far the greater portion of our hydrocarbons are manufactured.

These, indeed, are common enough; but this one, prepared in Nature's laboratory, enjoys properties peculiar to itself, which render it specially interesting, and of the greatest importance in the arts. It will be as well to run over these cursorily at first, as they will call for fuller detail, when speaking of its manufacture and applications.

1. *Lightness.*—The specific gravity of the rubber made from the *Ficus elastica* is about 0·92, and of that from the Siphonia 0·94.

2. *Elasticity.*—In this respect it stands almost without a rival. After being softened by immersion in warm water, it can be drawn out to about eight times its natural length, to which it will return again on the tensile force being withdrawn. Its elasticity, moreover, can be suspended, and restored again at pleasure.

3. *Resistance to Pressure.*—This is the converse of the preceding. Whatever the compressive force that may be applied, the Indian rubber will recover its original bulk on the pressure being withdrawn.

4. *Insolubility in, and Imperviousness to Water.*—These qualities, coupled with the fact already mentioned of its being lighter than water, suggest at once a multitude of applications, if only the difficulties of manipulation are surmounted. How that is done will be seen presently.

5. *Resistance to the Action of Alcohols, Acids, and Alkalies.*—These qualities are of especial value to the experimental and manufacturing chemist.

6. *Resistance to Atmospheric Influences.*—The only important exception seems to be in respect to exposure to sunlight. In this case an oxidation of the substance takes place, which changes its character altogether; but the action only takes place if the rubber is kept perfectly dry.

7. *Non-conduction of Electricity.*—This is a circumstance of no little importance in connection with one of the most important developments of modern science, the submarine telegraph.

NOTABLE INVENTIONS AND INVENTORS.

XXXIII.—CHLOROFORM.

BY JOHN TIMBS.

THE employment of *anæsthetics*, or substances for producing temporary insensibility to pain, had been known and practised for ages before it was discovered that by the use of chloroform pain might be put completely under the dominion of the human will. *Anæsthesia*, as such agency is termed, was known 1,800 years ago, when the Greeks and Romans used the root of the mandrake "to cause insensibility to pain in those who are to be cut or cauterised; for, being thrown into a deep sleep, they do not perceive pain." Pliny tells us that the juice of mandragora had a narcotic effect as a remedy for injuries inflicted by serpents, and before incisions were made in the body, in order to ensure insensibility to pain. "Indeed," he adds, "for this last purpose, with some persons, the odour of it is quite sufficient to induce sleep." "Again, by drinking mandrakes with wine," says Apuleius, "a limb may be cut off without any sense of pain." All narcotic medicines will produce conditions of anæsthesia in which surgical operations may be performed without pain; and during the operation of alcohol on the nervous system in drunkenness, operations have been performed without the knowledge of the patient.

It has been discovered by M. Stanislaus Jullien that the Chinese, in the third century of our era, employed an anæsthetic agent, in the same manner as we use chloroform and ether, for producing insensibility during surgical operations. It is stated that Hoa-tho, who flourished between the years 220 and 230 of our era, gave to the sick a preparation of chanvre (*ma-yo*), when, in a few moments, the patient became as insensible as one plunged in drunkenness, or deprived of life; then, according to the case, he made incisions, amputations, etc. After a certain number of days the patient found himself re-established, without having experienced during the operation the slightest pain. This *chanvre* is prepared by boiling and distillation, and is set down as the Indian hemp, which is taken even now by the Arabs to produce agreeable intoxication. Theodoric, a surgeon in the latter half of the thirteenth century, in his work on surgery, mentions "a flavour for performing surgical operations," made of "opium, mulberry, henbane, hemlock, mandrake, wood-ivy, and lettuce, to be boiled until concentrated in a sponge, which, when wanted, was to be warmed, and applied to the nostrils of him who is to be operated on, until he has fallen asleep; and so let the surgery be performed." In 1579 Bulleyn described "the possibility of setting patients into an anæsthetic state during lithotomy, etc.," by the use of mandrake.

The narcotic and anæsthetic properties of Indian hemp were known to the Scythians, who inhaled the fumes of hemp-seed thrown upon red-hot stones; and Indian hemp has been set down as the *Nepenthes* of Homer, which was brought from Egyptian Thebes. Bang, which is prepared from Indian hemp grown in Africa, is taken by criminals who are condemned to suffer amputation; and Sir Joseph Banks testifies to this use of it. This hemp is smoked in Congo, Angola, and South Africa; its leaves, seeds, and flowers are pounded and mixed with a confection, a piece of which, the size of a walnut, when eaten, will deprive a man of reason, and is described as "the increaser of pleasure."

Towards the close of the last century, Lassard, a surgeon of Paris, recommended the employment of a narcotic previous to serious and painful operations; and in a work by Meissner, in 1782, it is stated that Augustus, King of Poland, was surreptitiously narcotised by his favourite surgeon, Weiss, while a part of his foot, which had mortified after being wounded, was cut off without pain or consciousness. Shakspeare, in "Cymbeline," describes the imagined effects of subtle distilled potions, producing, without danger, a prolonged state of death-like sleep or lethargy.

The history of the various anæsthetic agents is interesting; but it was only by the science of chemistry that the seekers after a perfect anæsthetic agent were guided in the true direction; and it was ascertained that by means of the inhalation of various kinds of gases many maladies would become amenable to the power of the physician. In 1799 Humphry Davy breathed nitrous oxide, which he found to lessen the pain of cutting a wisdom-tooth; and although he did not succeed in establishing nitrous oxide as a medicinal agent, in describing the effects of this gas he predicted that, "as nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may, probably, be used with advantage during surgical operations in which no great effusion of blood takes place." Nor was this an accidental conception of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea which has become one of the most glorious realities of the present century. Davy also foretold that pneumatic chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded, "it is probable that pain would have been put into subjection to the intellect at the very beginning of the present century."

Forty-four years had, however, to elapse after Davy's

announcement that, "as nitrous oxide seems capable of destroying physical pain, it may probably be used with advantage during surgical operations," before this pregnant suggestion was acted on. In 1818, an article believed to have been written by Mr. Faraday, and published in the *Quarterly Journal of Science*, describes the great resemblance between the effects of the vapour of ether and those of nitrous oxide gas. In 1844, Horace Wells, a surgeon-dentist of Hartford, Connecticut, United States, having inhaled the gas, another dentist, Dr. Rigg, drew one of his teeth without pain, and Mr. Wells, after recovering from the inhalation, exclaimed, "A new era in tooth-drawing!" He then made other experiments, with various success; but a failure so annoyed him, that he became unsettled, came to England, returned to America, and at length died by his own hand, in January, 1848. Within three months Dr. Bigelow, of Boston, United States, removed a breast from a patient who had been rendered insensible by inhaling nitrous oxide. Next, Morton, Wells's pupil and partner, and Dr. Jackson, took up the idea, and having discovered that ether was much preferable for this purpose to nitrous oxide, they made known the important fact that under the influence of this agent insensibility might be produced under which persons might undergo the most severe operations without pain, and might be restored from this condition without injury to their health. On September 30, 1846, by the inhalation of ether Morton made himself unconscious during eight minutes; he also persuaded a patient to inhale ether from a handkerchief, and then extracted a bicuspid tooth, of which the patient knew nothing till he recovered his senses. The remedy was afterwards frequently used. Notwithstanding this success, the American medical journals condemned the discovery as a quackery, confirming the proverb, that "a prophet hath no honour in his own country;" the English journals, however, at once rightly appreciated it, though in November, 1846, the Paris surgeons received the announcement with all but indifference. Velpeau politely declined even to test its worth; yet, in January, 1847, the two great surgeons, Velpeau and Roux, averred, in the presence of the two Academies, that the discovery was "a glorious conquest for humanity."

In London the action of this new agent was extensively tried, and rightly appreciated. In January, 1847, the first experiment was made in England by employing the inhalation of sulphuric ether as a means of rendering surgical operations painless. The application had been communicated by Morton to Dr. Boott, of No. 24, Gower Street, who described it to Mr. Robertson, the surgeon-dentist, also of Gower Street. This gentleman, on the following day, operated upon a lady thrown into sleep by the inhalation, during which a molar tooth was extracted from her lower jaw. The inhalation occupied a minute and a half, and the patient's recovery from sleep another minute. Dr. Boott questioned her respecting the tooth, and she expressed her great surprise at finding that it was removed. She said that all she felt was merely a sensation of cold around the tooth, a sensation which was caused, perhaps, by the coldness of the extracting instrument. The apparatus employed consisted of the lower part of Nooth's apparatus, with a flexible appendage, to which was attached a ball-and-socket valve and mouth-piece, similar to those commonly employed for inhalation, together with a nasal spring. The full effect of the vapour was produced in from one to two, or three minutes generally, and as soon as it was perceived, the operation was performed.

Among the early cases recorded is that Mr. Liston, of University College Hospital, on December 21st, "amputated a thigh, and removed, *by evulsion, both sides* of the great toe-nail, without the patient being aware of what was doing, so far as regards pain;" he heard what was said, and was conscious, but felt neither the pain of the incisions, nor that of tying the vessels. Next, a patient in the Royal Infirmary, Edinburgh, was etherised, and had a limb amputated by Dr. Duncan, "without the infliction of any pain."

"Alas! that we must close this brief history of the discovery and application of the anæsthetic properties of ether, by stating that Morton shared the fate of almost every discoverer, viz., poverty, and the danger of being deprived of the honour of the discovery. The excitement of it injured his health. Having taken out a patent for it, and hoping, doubtless, that it would make his fortune, he neglected his business. Jackson, although he was content to get only a third share of the patent, claimed the whole merit of the discovery in a paper which he sent to the French Academy, and in which he suppressed Morton's name. Chloroform quickly superseded ether, and Morton found his patent valueless, his business destroyed, and even the bare honour of the invention wrested from him. But the pain with which we think of his misfortunes is greatly lessened by the knowledge of his attempt to keep his discovery a secret, and, under the name of 'Letheon,' to secure the possible profits of it exclusively for himself, by means of a patent, contrary to the usages of the profession." (Dr. Chapman, *Westminster Review*, 1859.)

A month after the first application of ether in England, Dr. Simpson, of Edinburgh, discovered that by its instrumentality the ordinary pains of maternity might be averted without danger. The remedy was used also, with a greater or less degree, in some of the most fearful and painful diseases; and by its aid many persons were rescued from certain death who must otherwise have undergone a difficult and most painful operation.

Ether, the first agent employed in this great revolution, is said to have been known to Raymond Lully and Basil Valentine the alchemists. In 1540 Valerius Cordus described the method of making it—the *oleum vitrioli dulce*, as he termed it. It consists of 4 atoms of carbon, 5 of hydrogen, and 1 of oxygen. It is usually procured by distilling common alcohol (the hydrated oxide of ethyle) with sulphuric acid; hence its usual name of sulphuric ether; its present chemical name is oxide of ethyle. "Ether," says Dr. Frobenius, "is certainly the most noble, efficacious, and merciful instrument in all chemistry and pharmacy, inasmuch as essences and essential oils are extracted by it immediately, without so much as the mediation of fire, from woods, barks, roots, herbs, flowers, berries, seeds, etc., from animals, and their parts, too."

The mixture, improperly called chloric ether, which is simply a solution of chloroform in alcohol, was, early in 1847, demonstrated by Mr. Jacob Bell to possess anæsthetic power. He exhibited its effects at St. Bartholomew's and Middlesex Hospitals. Mr. Waldie, of the Apothecaries' Hall of Liverpool, first acquainted Professor Simpson with the properties of chloric ether, which was mentioned during conversation, and Mr. Waldie being well acquainted with its composition, and with the volatility, agreeable flavour, and medicinal properties of chloroform, recommended the professor to try it. Acting on his advice, Dr. Simpson procured chloroform, undiluted, discovered the effects of its vapour, and thus bound his name indissolubly with one of the greatest boons ever conferred on man.

FARMING AND FARMING ECONOMY.

XVII.—FATTING CATTLE.

By Professor Wrightson, Royal Agricultural College, Cirencester.

Cattle may be fattened at any age. Calves, yearlings, and two-year-olds have all been made ready for the butcher, but the usual and best plan is to delay the process until the animal has arrived at something like maturity. This, owing to the improvement which has been effected by breeders of stock, takes place much sooner than was formerly the case, and at two-and-a-half years old steers commonly find their way into the fatting stalls.

In the management of fatting cattle care must be taken that the animals are quiet and comfortable, and that they are regularly supplied with sufficient quantities of suitable food and water. Each of these points is important, and we are therefore led to inquire, how cattle are best made comfortable? What is a sufficient supply of food? What foods are most suitable for fatting stock? and afterwards we shall discuss the questions of cost and return.

ACCOMMODATION FOR FATTING CATTLE.

Cattle are fed in fold-yards, boxes, and stalls, or byres. As we intend on a future occasion to devote a chapter to the subject of farm buildings, we defer the consideration of the structure and dimensions of these several kinds of accommodation. Small, well-shedded and spouted (troughed) fold-yards, protected from the north and east, give excellent shelter; but, owing to their being open and exposed to rain, they require a

large quantity of straw to be used as litter. The manure made in fold-yards suffers in quality from this reason.

The *box* system provides a separate apartment for each animal, and the boxes being arranged in a continuous series, the cattle have the advantages of society without any of its annoyances. Heifers, being apt to fight with each other, are the better for this restraint. Boxes, besides the above advantages, necessitate a smaller amount of straw as litter, and ensure a high quality of manure, owing to the protection they afford from rain.

The *byre* is almost universally employed for milch-cows, and is also used for fatting cattle. Tying up animals for long periods of time, as in the case of fatting cattle, is however unnatural, and unless the curry-comb and brush are freely used, they soon become dirty in the coat, the hair falls off in patches, and the skin becomes irritable. The hoofs of cattle so confined also grow to such an extent as to be impediments to the progress of the unfortunate animal, when at length he has to be driven to the shambles. These evils may with proper care be avoided, and this being granted, the byre possesses solid advantages. Where space is an object, no system of housing will accommodate so large a number of cattle in a given area, and it is the most economical method with regard to straw. The manure is, however, not well mixed, owing to the constrained position of the animals, and for this reason the litter ought to be daily removed, and spread evenly over a fold-yard, there to be further trodden down by young stock, and turned over by pigs. Whatever system is adopted, it is essential that the animal should have a comfortable bed, be protected from cold winds, supplied with water, and kept quiet.

FOOD AND FEEDING.

The selection of suitable foods and the best methods of giving them are the most important considerations in feeding cattle. We do not propose to study the chemistry of foods, but rather to adhere to a simple statement of the best agricultural practice. Accordingly, we find a few well-known vegetables and vegetable products employed for this purpose, among which we may name the following:—Turnips, swedes, mangel, hay, straw, grass, clover, vetches, and other root and forage crops; also linseed, cotton, rape, and poppy seed cakes; barley, bean, and pea meal; lentils, locust beans, Indian corn, buckwheat, millet, and many other similar substances which, from time to time, are brought before the attention of farmers. There are also artificially prepared cattle foods, such as Thorley's, Beache's, and Simpson's, which may be used with advantage as condiments in exceptional cases, but are too expensive for general purposes. Of these feeding materials, the first few mentioned are those most generally employed.

Cattle-feeding is carried out upon the most simple principles in the north of England and Scotland. There, an abundant crop of swedes may be generally obtained, and these of higher quality than the roots grown in the south. Comparing north and south country practice, we have in the former case heavy root-crops of superior quality, and in the latter case precarious and light root-crops of inferior quality. This alone must make a great difference in the practice of cattle-feeding, and hence we find that while in the north the staple foods are turnips and straw, supplemented at the later stages by comparatively small quantities of cake and meal, in the south of England the amount of roots is lessened, while that of the "artificial" or dry foods is very much increased. Appliances such as the chaff-cutter, the root-pulper, and apparatus for cooking food, have also found more favour in the south than in the north. Were we to describe cattle-feeding as carried on north of the Tyne, our task would be sufficiently simple. There, fresh or "forward" beasts are placed in folds or boxes, supplied with a liberal allowance of turnips and straw, and as they approach fatness, with from 3 to 7 lbs. of linseed cake or a "crowdy" of meal. In the summer of 1866, the writer visited some of the best farmers in Berwickshire and Lothian. At Edington Mains, Mr. Wilson's cooking apparatus had not been used for the last year or two, and a general impression seemed to exist that the old method of turnips and straw, supplemented with from 5 to 7 lbs. of cake or corn, was after all the most successful plan. One great object of cattle-feeding in Berwickshire is to crush down straw into manure; and to this end, it is extremely common in good homesteads to find the yards unspouted, so that the rain-water may do its part in turning the straw into manure. "Mr. Lyal's (Green Knowe, Gordon) method of feeding cattle is simply turnips and straw, both given whole, and supplemented by moderate quantities, 5 to 7 lbs., of oilcake. The fold-yards are also kept unspouted, so that the rain-water may help the crushing of the straw into manure." (*Agricultural Gazette*, Aug. 27, 1866.)

Mr. Wilson, of Edington Mains, tells us in his "British Farming," 1862, that "important changes have now been introduced," but the day is still distant when the pulper, the chaff-cutter, and other improvements will become general. The plan pursued in the south may be illustrated by the practice followed on the College Farm, Cirencester (1866), where the cattle are placed in boxes, and receive a liberal allowance of cake and corn, chopped straw, a little hay, and a very small allowance of roots. From 50 to 100 lbs. of roots may be reasonably given to a fatting bullock, but in the case just cited they generally only receive 20 lbs.—a smaller quantity than we have ever known given, except in cases in which cattle are fed without roots. The amount of food varies with the weight and condition of the bullock, and is gradually increased towards the end of the fatting period as follows:—The cattle commence in October with 5 lbs. of meal, 2 lbs. of cake, 20 lbs. of roots, chaff, and a little hay. In November the food is changed to 7 lbs. of meal, 2 lbs. of cake, and roots, chaff, and hay as before. In January the food is again changed to 9 lbs. of meal, 2 lbs. of cake, 1 lb. of "cattle food," roots, etc., as before. This is continued until the termination of the fatting process. The food should be given regularly, and often. Thus on the College Farm the cattle are fed seven times a day:—

At 5.30 to 6 a.m., meal, chaff, and a few turnips (just to moisten the chaff).
At 7.30 to 8 a.m., 20 lbs. of sliced roots.
,, 9.30 a.m., meal and chaff.
,, 12.0 a.m., oilcake and chaff.
,, 2.0 p.m., meal and chaff as before.
,, 4.30 p.m., ditto, ditto.
,, 6.0 p.m., 4 lbs. of hay.

The quantity of meal and cake will vary as above, but it is divided pretty equally—the 4.30 meal being, if anything, the heaviest.

In a prize essay contributed by Mr. Dobito to the sixth volume of the *Royal Agricultural Society's Journal*, a very good system of cattle-feeding is explained. Mr. Dobito commenced with tankard white turnips, and 7 lbs. of pollards per day. Early in November the following system was practised:—The first thing in the morning the cattle received 1 bushel of swedes, cut small in a Gardner's sheep turnip-cutter. When these were eaten, the troughs were cleaned out, and the animals then received 2 lbs. of oilcake, 3 lbs. of pollards, and a little hay chaff. While eating this the litter was removed, the floor made clean, and each bullock was brushed with a whalebone horse-brush. The cattle were then left to ruminate and rest. At midday each bullock received another bushel of swedes, and a repetition of the dry food with the addition of 3 lbs. of bean meal. According to this very liberal system of feeding, each bullock received 13 lbs. of cake and meal, hay, and 2 bushels of cut swedes. We conclude our account of cattle-feeding by abstracting a sentence or two from Mr. H. M. Jenkins's report upon the farm of the late Mr. Hudson, of Castle Acre, Norfolk (1869). From 100 to 140 beasts, steers (mostly shorthorns), are bought in every year at Peterborough Fair. These steers are placed in small well-shedded fold-yards, and receive 2 bushels of roots and from 10 to 12 lbs. of linseed cake each per diem, as well as a bushel of cut hay or cut straw after the hay is finished. They begin to go off fat in January, and ought all to be sold by May.

COST AND RETURN.

The cost of fatting a bullock has often been stated to be at the rate of from 6s. to 7s. per week. It is by no means easy to arrive at an absolute result, as much depends upon the price at which the green food, turnips, and other home produce, not usually marketed, are valued. Taking a liberal system such as that employed by the late Mr. Hudson, of Castle Acre, the linseed cake alone would, at £12 per ton, cost 1s. per day, and the hay, roots, and attendance might increase the amount by 6d., making in all 1s. 6d. per day, or 10s. 6d. per week. Mr. M'Combie, of Tillyfour, Aberdeenshire, considers his show bullocks cost him above 12s. per week, while another agricul-

turist has estimated the cost of ordinary fatting cattle as low as 6s. per week. The cost of feeding cattle of ordinary size may be thus calculated:—

	d.
6 lbs. of linseed cake per day, at £12 per ton	7·7
4 lbs. of barley-meal, at £8 per ton	3·2
56 lbs. of turnips, at 5s. per ton	1.5
5 lbs. of hay, at £4 per ton	2·1
Attendance at the rate of $\frac{1}{40}$ of the wages of one man, at 14s. per week	0·6
	15·1

According to this estimate, the cost would amount to 15d. per day, or 8s. 9d. per week.

The question of return is still more difficult to solve. Cattle pay for their food by the manure they leave, as well as by beef produced. The fact that cattle are looked upon by many agriculturists as mere manufacturers of manure, indicates that there is not much direct profit. In other words, if an animal pays for all that is expended upon it without leaving any profit, the farmer is still satisfied, because he has the manure for his land. If a bullock lays on 1 stone (14 lbs.) of beef per week he is doing well, and a glance at the foregoing estimates of cost clearly shows that, with beef at 8s. or even at 10s. per stone, there is no great room for profit, while at the same time neither interest nor risk is charged. We have heard of bullocks increasing at the rate of 3 lbs. per day, but this must be viewed as an extreme case, doubtless caused by an extra allowance of food. In spite of the recent high prices of butcher's meat, it is therefore evident that the winter feeding of bullocks is not highly remunerative, when the grazier purchases lean stock at an extravagant price. Either by very judicious and fortunate purchases, by taking advantage of favourable changes in the market, or better still, by bringing up calves, and thus avoiding the extreme prices now realised by lean stock, the fattening of cattle may be made a profitable occupation to the agriculturist.

SHIP-BUILDING.—XX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

WATER-TIGHT FLATS.

NEAR the extremities of ships, and below the lowest complete deck, partial decks or platforms are very often constructed, to form the floors of store-rooms, etc. These platforms are usually supported upon light beams, and in some cases are of considerable length. In addition to their usefulness in the particular just stated, they add to the strength of the structure, forming strong ties between opposite sides, and helping to support the bow in case of collision. This is true in all classes of ships, whether wood, iron, or composite; but in iron ships such platforms can, by means of light plating worked upon the beams, be also turned into horizontal water-tight partitions, adding much to the safety of the vessels. In fact, this method of water-tight subdivision is well adapted for use at those parts where the forms of ships necessarily become very fine, and is probably preferable to other methods of subdivision. As an example in point, we may refer to the iron-clad ships of the navy. Their double bottoms do not extend throughout the length, but only over, say, two-thirds of the length, leaving something like one-sixth of the length at the bow, and another one-sixth at the stern, without the protection of an inner skin. At or near the endings of the double bottom, transverse water-tight bulkheads are placed; and from these bulkheads to the extremities water-tight platforms, or flats, are built. The sizes of the compartments so enclosed are not large, because the form is very fine at these parts; and they are subdivided in nearly all cases by transverse bulkheads, as well as by the partitions built in the hold for special purposes—*e.g.*, for stowing the cables, provisions, and stores, for enclosing the shaft-passage, etc. By all these arrangements a comparatively minute water-tight subdivision is secured, without fitting an inner skin; and the advantage gained will be seen more clearly when it is considered that the section of the flat, at any cross-section of the ship near the extremities, corresponds roughly to the base of a triangle, of which the two sides would have to be plated over if an inner skin were fitted. In the *Great Eastern*, we believe, the inner skin is continued quite forward to the bow, but ended some distance from the stern. Mr. Scott Russell has, however, since expressed the opinion that it would have been better not to have followed this course; and from the foregoing considerations the reason will be obvious.

It need hardly be said that all openings or hatchways made in water-tight flats, for the purpose of gaining access to the spaces below them, must be supplied with water-tight covers of some kind. It very often happens that the spaces below the flats are not made use of, being very confined, and only visited for the purpose of inspecting and cleaning or painting the framing and plating. The openings, or man-holes, in the flat can then be closed by simple plate-covers, secured by nut-and-screw bolts, red-lead or some other material being used as a "stop-water" in the joints, and the covers being nearly always in place. Where use is made of the space below a flat for stowage—as is not uncommon in large ships—it is necessary to leave the hatchways open under ordinary circumstances, providing some form of scuttle or cover that can be quickly closed and secured in case of need. One of the simplest and best plans is to hinge the scuttle to one side of the framing round the opening in the flat; and then on any sudden alarm the scuttle can be turned down into the rabbet formed to receive it, its security being ensured by catches similar to those fitted to hinged water-tight doors. India-rubber beading is also commonly fitted in the rabbets of these scuttles to make the joints water-tight. Other plans of scuttles have been fitted, but we need not describe them, as they are only minor features of construction.

It will be remembered that the main objection to the use of closely-spaced transverse bulkheads in merchant ships is based upon the difficulty which ensues in stowing the cargo. Admitting the force of this objection, some persons have proposed to substitute horizontal flats for transverse vertical partitions, and so to leave *long* cargo spaces without rendering the individual water-tight compartments so large as to compromise the safety of the ship. One of the best schemes of this kind was patented by the late Mr. Lungley, who termed it a plan for constructing "unsinkable" iron ships. It may be briefly described as follows:—The cargo-hold is subdivided by several horizontal platforms, formed of water-tight plating. To each of the spaces thus enclosed, access is obtained by means of a water-tight "trunk" or "shaft," leading up to the height of a deck, situated considerably above the loadwater-line. Cargo would be introduced into the several spaces down through these trunks; and it will be obvious that if any one of the compartments were "bilged," the water which entered would be confined to it, and to the trunk connected therewith. The lowest water-tight flat really constitutes an inner skin, as it was intended by Mr. Lungley to place it so low down in the vessel that no cargo should be stowed below it. In steamships, the intention was to place the machinery in compartments constructed on the usual plan, with transverse bulkheads; and other transverse subdivision was to be introduced where it did not interfere with the stowage. Although favourably mentioned by several authorities, this plan has not found favour with ship-builders, nor does it seem likely to do so. It involves additional cost in construction, and moreover does not lend itself so readily as other plans to the efficient combination of structural strength with lightness and safety.

It may be interesting to refer in passing to other proposals that have been made again and again, especially in connection with ships of war, to render them practically unsinkable by means of minute water-tight subdivision. The matter is deserving of attention, because the progress made in the construction of powerful guns, the use of torpedoes, and the employment of steam-rams, has led many persons to believe that the use of armour-plating for the protection of war-ships will have to be discontinued, and "unsinkable" unarmoured ships built instead. Into this discussion it would be out of place to enter here; but it should be noticed that great practical difficulties would require to be overcome, before the subdivision could be made so minute as to give the desired degree of safety. Room must be had, for example, for the engines and boilers, and so some large compartments must be formed. Moreover, convenience of stowage in magazines, shell-rooms, store-rooms, etc., would have to be sacrificed, and all facilities for communication between different parts would be done away with. Improvements

in many respects, particularly in the construction of marine engines, may do much to remove these difficulties; but at present the preferable and most natural course appears to be that actually followed in our armoured ships—viz., to provide a good double bottom and numerous main transverse bulkheads; then utilise to the utmost possible extent the partitions erected primarily from considerations of stowage; and supplement this by such further water-tight subdivision as may be conveniently applicable.

PARTIAL BULKHEADS.

A description has already been given (Vol. III., page 182) of the partial bulkheads, or deep plate-frames, fitted in ships built on Mr. Scott Russell's longitudinal system. Strengthenings of a very similar character are sometimes fitted in ordinary iron vessels, with transverse framing, at parts where special transverse strength is required, or in cases where experience proves that the strength provided originally was insufficient. With numerous transverse bulkheads they are not, of course, needed; but when the cargo-holds are very long, and especially at parts adjacent to the main hatchways, where the decks are cut away considerably, such partial bulkheads are of considerable value. They consist simply of a deep plate-frame with single or double angle-irons on the edges. The plate-frame has often to be made in several lengths, which are well fitted and strapped at the butts, in which case the frames extend from gunwale to gunwale. In other cases the partial bulkheads are only extensions of the main transverse bulkheads, being fitted above the decks at which those bulkheads end. The latter arrangement has been adopted also in a few wood ships, which have transverse bulkheads in the hold and iron deck beams.

Under this head it will not be out of place to describe briefly the stern strengthenings fitted to the recent wood-built screw steam-ships of our navy. One of the great difficulties to be overcome in constructing such vessels, is to give to the overhanging stern that amount of strength which is needed to resist the severe local strains produced by the action of the screw propeller. The weakness at the stern displayed by many merchant steam-ships built of wood, had much to do with the rapid introduction of iron steamers; and in some of the finest unarmoured wood ships of the navy similar weaknesses were developed, the stern drooping and working considerably in spite of the precautions taken. Various means were tried to obviate this evil, one of the most common being the use of strong metal knees bolted under the ship's counter, and against the sides of the stern-post. Again and again, however, these knees were broken, until they were made of massive proportions, and even then the strains due to the propelling apparatus were not satisfactorily met in vessels with great steam power, until a simple but efficacious arrangement of internal iron strengthenings was devised, which has proved most successful in all cases. Its main features are as follow:—

The beams of the deck to which the upper ends of the stern-posts are connected are covered with strong iron plating, from the fore or body post to the stern. Between the two posts, and upon the inside of the counter, a strong iron-plate knee is fitted at the middle line, and connected with the posts and the counter by double angle-irons. In wake of each post, and between it and the ship's side, strong transverse bulkheads are fitted, their upper edges being riveted to the deck plating, and their other edges connected with the posts and the ship's sides by double angle-irons. The upper parts of the posts, within the ship, are covered with strong iron plates, in order to ensure a satisfactory connection between them and the iron strengthenings. It should be added that large holes are cut out of the central portions of the transverse bulkheads—thus turning them into "partial" bulkheads—and that stiffening angle-irons are fitted around the edges of these holes. These main strengthenings are supplemented by iron hooks and braces on the lower part of the stern before the body-post, by short iron flats on the lower-deck beams, and by external metal knees under the counter, all of which contribute to the rigidity of the stern.

Iron screw-steamers, even of the greatest power, can be made sufficiently strong at the stern without any of these supplementary strengthenings. In the extremely fine part of the run abaft the stuffing-box bulkhead, it is usual to form the lower portions of the transverse frames of lightened plates, with angle-irons on the edges, and in some cases horizontal frames, or flats, are combined with these transverse frames. No other features worthy of note on account of their speciality are generally adopted.

HOG-FRAMING, ETC.

Under this head, we desire to glance at some special forms of longitudinal strengthening used in American river steamers, and a few other vessels, but not common in sea-going ships.

It is well known that American river steamers have enormous superstructures built upon comparatively light and shallow hulls, being in fact floating hotels of two or three storeys in height. Moreover, their weights of engines, boilers, etc., are disposed in a very unusual manner, being often concentrated in very short spaces of the length; and this fact, taken in connection with the excessive fineness of form given to the hull, in order to attain high speed, renders the longitudinal bending strains brought upon the structure very great. The question arises, therefore, how is the necessary strength supplied, seeing that the superstructure is built almost exclusively with a view to accommodation, and helps the hull proper scarcely at all? And the answer is, by means of the hog-frame, or some similar plan. These hog-frames are really strong timber girders, capable of resisting either tensile or compressive strains, and are sometimes two or three times as deep as the hull proper. When so high they are built as follows:—Strong vertical struts of timber are erected, and strongly secured at the heels to some portion of the hull. Upon the heads of these struts a strong longitudinal scarfed beam is fitted, and forms the top of the girder. Diagonal struts are also fitted between this beam and the hull, in order to maintain the rigidity of the girder. Our meaning will perhaps be more clearly understood, if we say that these hog-frames may be fairly compared to the side-girders commonly fitted to timber bridges, and help the shallow hull just as those girders help to sustain the platforms of the bridges.

In cases where less strength is required, shallower hog-frames will suffice, and sometimes these are built in the hold, the vertical struts then being heeled on strong longitudinal keelsons, and made to extend up to longitudinal beams fitted under the lowest tier of deck-beams. It is interesting to remark that this latter arrangement, which is now extensively used in America on the western rivers, is identical in principle with a plan proposed by the great French writer Bouguer, more than a century ago. He was much impressed with the excessive hogging commonly occurring in the ships of that period, and to remedy it, proposed to construct what we should now call a hog-frame at the middle line, the keelson forming the lower flange of the girder, and a continuous carling or longitudinal beam being fitted under the lower deck beams. This plan is obviously applicable to sea-going ships, but the first-mentioned, where very deep hog-frames are employed, would scarcely be so. Of course, river steamers are not subjected to such severe strains as sea-going ships have to resist; but, on the other hand, the latter class in nearly all cases have the hull proper much deeper than that of river steamers, and (as was before shown) this increase in depth leads to a very great addition of strength in the hull itself, supplementary strengthenings not being so requisite, if at all required.

Before passing on, it may be interesting to add that the Americans generally end their hog-frames at fifty feet or so from the ends of the steamers, and that they support the extremities by means of what they term "masts and guys." This is a very simple but apparently effective device, and consists in erecting strong masts at parts of the ship where there are excesses of buoyancy, and then leading chains or "guys" from the tops of the masts down to parts, especially near the bow and stern, where there is an excess of weight. It will be obvious that, while this plan may answer very well in river steamers, where the strains at the bow and stern always tend to make those parts droop, it would not be applicable to sea-going ships, which when at sea may be subjected to sagging strains throughout the length. The guys are, of course, only efficient against tensile forces, and are only strained in that manner in the cases where they are employed; they are also subjected to no sudden and great variations of strain, like those experienced by the structure of a ship at sea. We mention these arrangements, therefore, rather as examples of simple plans adapted to particular uses, than as suited for general application, or as illustrating principles of construction.

In some iron and steel shallow-draught vessels, built for

service in the rivers of India and elsewhere, lattice-girders, serving the same purpose as hog-frames, have been fitted. With iron or steel, such girders can be made both stronger and lighter than when built of wood, and are also most simple in construction. It may be that hereafter girders of a somewhat similar character will be used as strengthenings in sea-going ships, if their dimensions be much increased as compared with our present ships, and a longitudinal system of framing be adopted. In bridge-construction the lattice principle is now very extensively employed; and, although not so well adapted to ship-building, it appears probable that the same principle may be applied to some extent with advantage.

In concluding these remarks on some of the principal special provisions for strength and safety, we would once more remind our readers that, within the limits of this series of articles, it is impossible to do more than sketch the main features of ship-construction; and we would refer such as may desire a fuller acquaintance with the subject, to the numerous published works giving detailed information.

MINING AND QUARRYING.—XXIX.

BY GEORGE GLADSTONE, F.C.S.

SILVER.

ORES—ASSOCIATION WITH GALENA—GEOGRAPHICAL DISTRIBUTION—ASSAYING—SEPARATION OF SILVER FROM LEAD—PATTINSON'S PROCESS—ACTION OF ZINC.

STRICTLY speaking, it can hardly be said that we possess any silver ores in the British Isles, though, as has been stated in Article XXIV., the production of silver in this country is very considerable. It is true that specimens of native silver, as well as some of its ores, extracted from British mines, are to be found in mineralogical cabinets; and also that some of the Cornish mines have yielded native silver, and the sulphide and arsenide of silver to the value of some few thousand pounds sterling. In no case, however, have these mines been worked for the sake of this metal alone.

It is as an almost constant associate of lead that we look for our supply of British silver. Those ores of lead which occur in the older rocks, such as the lower Silurian and Devonian, generally contain the largest per-centage. Thus the lead ores of the Isle of Man yield fifty to sixty ounces of silver to the ton of lead, those of Cornwall and Devonshire about thirty ounces, those of Cardiganshire and Montgomeryshire fifteen to twenty-five ounces; while the great deposits of lead ore in the Carboniferous limestone often yield so little, as not to be worth the cost of separation. The annual yield from this source is steadily increasing; the average produce of the British mines for the ten years ending with 1868 was 666,804 ounces, while the two last of the decade contributed to this average 805,394 and 841,328 ounces respectively.

The principal European supplies are drawn from Spain, where genuine silver ores occur; from the Austrian Empire, in which the silver is for the most part associated with copper; and from Saxony and Prussia, where the ores consist principally of argentiferous lead.

More than three-fourths of the whole supply of silver comes from the New World. Mexico has always headed the list by far; but the great discoveries of late years in some of the most recent acquisitions of the United States, lead to the impression that before long Mexico even may be outdone by its modern rival. The whole of the mountain chain which may be considered the backbone of America, extending from the southern Andes in Chili to the Rocky Mountains in the north, is more or less argentiferous; and the produce throughout the whole length of this region would be very much greater than it is at present, were there a larger working population, and greater facilities of communication.

The assaying of silver ores, so far as concerns Englishmen, will principally have reference to the argentiferous lead; but something should be said as to how to treat silver ores proper, as they are always liable to be met with, especially in mining for copper. If they contain much earthy matter, they may generally be most conveniently treated by fusing them in an earthen crucible with some carbonate of soda and borax, and more litharge than is necessary to take up the silver in the ore, so as to yield an alloy which shall be moderately rich in the precious metal. The mixture is melted in an ordinary assay-furnace, until the slag has become quite liquid; it is then poured out into an iron mould, and on cooling, the button of alloy will be found at the bottom. This has then to be cupelled in order to separate the silver from the lead. The cupel, upon which this operation is conducted, is made of bone-ash ground up with water, pressed into a mould, and hollowed out in the centre. The cupel, which must first be perfectly dried, is placed in the muffle of an air-furnace, and gradually raised to a bright red heat. The button of alloy is then placed in the hollow of the cupel, where it soon melts; and the air passing through the muffle over the surface of the metal, oxidises the lead in the alloy, and converts it into litharge. This is absorbed by the bone-ash of the cupel as fast as it is formed, and so the silver is ultimately left behind in a state of purity. When cold, the bead of silver is taken out and weighed; from the weight has to be deducted the quantity of silver that may have been present in the litharge, and the result will be the quantity of silver in the ore. This correction for the silver introduced through the litharge is necessary in all exact determinations, but it occasions little trouble in practice, as one testing of the litharge will suffice for a whole parcel; the litharge itself is tested by cupellation, and if necessary, can be done simultaneously with the other.

If the silver ore contains a large proportion of the sulphides of other metals, it may be conveniently assayed by the scorification process. In this case, the pounded ore is put into an open earthen dish, with an excess of granulated lead, and some borax. This is heated to a bright red heat in the muffle of an assay-furnace. A portion of the lead being soon converted into litharge, enters into combination with the metallic sulphides, forming with them, the earthy portions of the ore, and the borax, a fusible slag; the excess of lead is thus protected from the action of the air, and remains in the metallic condition, uniting with whatever silver there may be in the ore. A button of silver lead is the result, which has then to be cupelled as before, and a proper allowance made for the silver originally contained in the lead.

The assay of silver lead ores has been partially described when treating of the inferior metal. For the purposes of sale, the ore must be assayed first to ascertain the quantity of argentiferous lead, and then the relative proportion of silver and lead in the product must be determined. From these two data, the value to the smelter can be calculated. The former part of the process has been detailed in Article XXIV.; and the latter will now need no further description than to say that it is done by cupellation, exactly as the button of alloy produced in the assay of silver ores is treated.

We must now turn to the separation of silver from its other associates on the large scale. The chief of them is lead. In former times it used to be separated from this metal by cupellation alone, a plan which is still adopted at many Continental works, but which has been almost entirely superseded in England by a more convenient one, known by the name of the inventor, the late Mr. Pattinson of Newcastle.

Pattinson's process is dependent for its action upon a curious property of the ordinary alloys of silver and lead—viz., that they melt at a lower temperature than pure lead does. This rule applies to any compound of the two metals in which the proportion of silver does not exceed 2¼ per cent.; but as this per-centage is equivalent to a yield of 735 ounces to the ton, it will be seen that the limit vastly exceeds in richness the produce of the most valuable ores. The consequence of the alloy melting at a low temperature is, that on slightly cooling the molten mass, a redistribution of the particles takes place, and a portion of the lead tends to crystallise out. By removing the crystals before the rest of the metal solidifies around them, and repeating this operation several times, the crystallised lead becomes almost entirely freed from silver, and the remaining alloy becomes gradually enriched with the precious metal, until it nearly reaches the limit above stated. The desilvered lead rarely contains more than one-half to three-quarters of an ounce to the ton, or about 0·002 per cent., beyond which point it is not found profitable to carry the operation.

The plan by which this process is carried out is as follows:—From eight to ten or more iron pots are placed in a row, and sunk into a platform of brickwork, beneath each of which is a

separate furnace, with a wheel flue passing below the whole of the under surface of the respective pots before passing away into the common chimney. Fig. 1 shows a cross section of the row of pots from back to front. A represents the pot sunk into the brickwork, B; C the furnace, with the ash-pit, D, below; E E E show the arrangement of the flue encircling the under side of the pot, before passing into the general flue F. The platforms G and H, for the men who attend to the pots, extend the whole length of the row. Each crystallising or Pattinson pot, as these are often called, is hemispherical in shape and about five feet in interior diameter. The outside pot on the left hand is rather smaller than the rest, and is distinguished by the name of the "market pot." Each of the crystallising pots will conveniently hold about 6½ tons of melted lead.

Suppose a series of ten pots are used, and that the crystallising pots are numbered consecutively 1 to 9, No. 1 being next the market pot. In all of them, with the exception of the market pot, there will be a quantity of lead more or less rich in silver remaining over from the last shift. The fires are got up, attention being first given to pot No. 5, the central one of the series, in which the process of separating the silver will be commenced. This pot is filled up with the lead to be desilverised, and the fire below it is kept up till the whole is thoroughly melted. As soon as this point is reached, the lead is skimmed, to remove all the oxide that has formed on the surface during the melting; the fire is withdrawn, and the lead is left to cool, cold water being generally thrown upon the metal to hasten the cooling. As soon as the lead begins to crystallise on the surface, and round the edges of the pot, one of the workmen detaches the adhering crystals by means of a long iron bar shaped at the end like a chisel, called a slice, and stirs them up among the still liquid portion. Another man then takes a perforated iron ladle, and dips it to the bottom of the pot, bringing up in it a quantity of lead crystals; with a slight jerking motion, they are pretty thoroughly freed from the liquid portion which runs through the perforations in the ladle, and the crystals are then turned over into pot No. 4, the next in order on the left hand of the workman. The ladling is thus continued till rather more than two-thirds of the contents of pot No. 5 have thus been transferred to No. 4, when the remainder, consisting of enriched lead, is removed by ordinary ladles into pot No. 6 on the right. The same process is now applied to pots 4 and 6, the crystals from these being ladled into Nos. 3 and 5 respectively, and the enriched lead into Nos. 5 and 7 respectively, and so on until the market pot is reached at the one end, and No. 9 at the other end, of the series.

Thus, if we suppose a lead to be operated upon which contains twelve ounces of silver to the ton, that will represent the richness of No. 5; but as the crystals will only carry away with them a small proportion of silver, the remainder (from one-third to one-fourth part of the whole) will generally be at least double as rich as it was before the separation, and No. 6 will, therefore, be worth about twenty-six to twenty-seven ounces to the ton. By this process of addition, as the mixed metals travel to the right from pot to pot, and of subtraction as they travel to the left, it will result that at the one extreme the lead will be found to contain some 250 ounces to the ton, while that in the market pot at the other will be practically desilverised, containing only about three-fourths of an ounce to the ton. The enriching of the lead can be carried higher if desired, but that is found to be about a convenient limit, as the crystals become each time more difficult to separate, and an alloy of such richness is well suited for the next step of the process, the cupellation.

The perforated ladles above mentioned are about sixteen inches in diameter across the bowl; and including the handle, weigh about 130 lbs.; at each lift the workman takes up about 250 lbs. weight of crystals. The handle rests, when the ladle is full, upon a block at the side of the pot which serves as a fulcrum, the long arm of the lever being in the hands of the workman; but, nevertheless, the work is rather heavy. In some establishments, therefore, cranes are used as a substitute for manual labour, a crane being fixed between each two successive pots; and then ladles which will hold double the quantity of crystals can be employed, pots which will hold about ten tons of metal being generally adopted in such case.

As the perforations in the ladles are apt at times to get clogged with the cooling metal, it is usual to have small pots, called temper or wash-pots, placed between every second crystallising pot, containing hot lead of the same richness as that in the pot from which the ladle has been taken. In some works, however, these are dispensed with, and the ladle is reheated by being dipped for a while in the hot lead contained in the pot to which the crystals are being transferred.

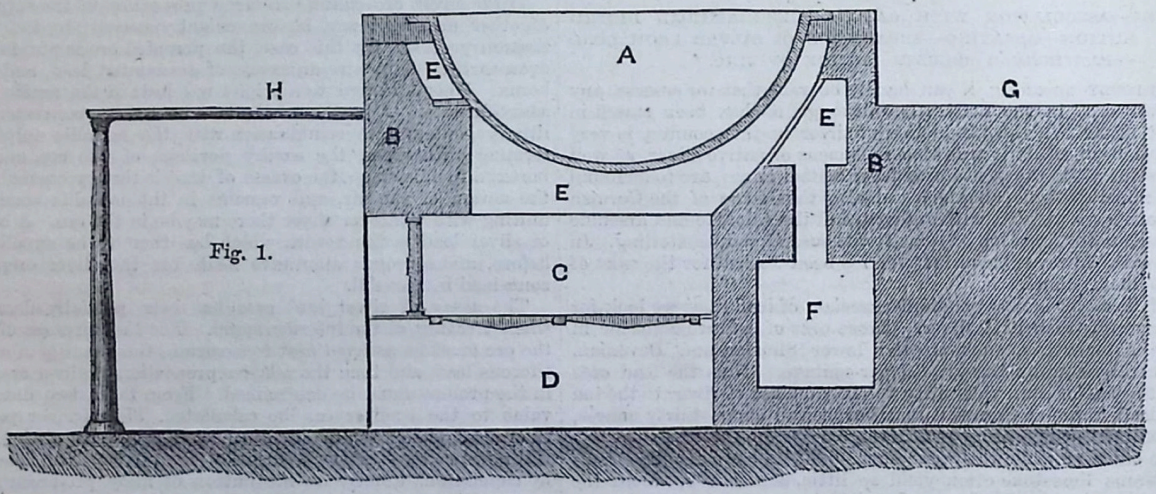


Fig. 1.

The loss of metal in skimmings, when a series of ten pots is used, will amount to nearly one-fourth of the whole quantity; but the skimmings are utilised by re-conversion into metallic lead, so that the ultimate loss is very small.

Silver may be separated from lead by other processes besides cupellation, and that of Mr. Pattinson; one of the most convenient of these, though it has not held its ground in competition with the others, is due to the action of zinc. It is found that if about 5 per cent. of zinc be added to any given quantity of argentiferous lead, and the metals be mixed together in a liquid state, the silver will separate itself from the lead and combine with the zinc; and as the latter has a higher melting-point than the former, the zinc on cooling will crystallise out first along with the silver, and form a layer on the surface of the lead, which can be separated with readiness. It will be remembered that in Article XXIII. zinc was spoken of as being highly volatile, and as silver is only very slightly so, the inferior metal can be removed by distillation in retorts made upon the Belgian principle; or it can be separated from the silver by dissolving it in weak sulphuric or hydrochloric acid. This principle, with certain modifications rendered necessary by the peculiar character of the ores from which the lead is made, has been adopted with greater success at some of the smelting-works on the Continent.

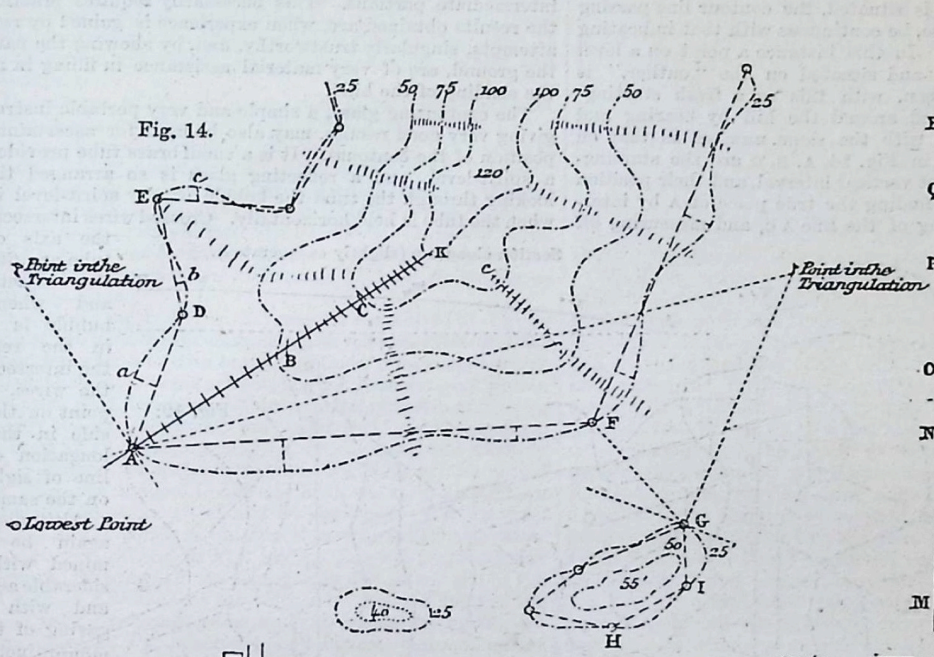
MAP AND PLAN DRAWING.—V.

By C. C. King.

METHOD OF CONTOURING.

It is not always absolutely necessary to run a system of contours or levels through an area, though whenever time is afforded it is advisable to do so, not only because of the greater accuracy of the relative heights of different points, but because it enables the draughtsman to obtain a much better appreciation of the intricacies of the country, and hence much facilitates his sketching those features. Where the extent of ground is not large, where the differences in level are very slight, or where again they are not numerous, as would be the case if a small solitary hill alone broke the general flatness of the surface, it would scarcely be worth while to trace regular contour lines; but as this would rarely occur, it will be well to treat contouring as a step in the work which can be omitted if the nature of the country does not demand its being carried out.

We have before defined what contouring is. It means simply describing level lines at stated regular intervals of altitude which intersect the area and follow the windings of the hills and valleys. It is evident, therefore, that some point must be selected to start from, and this is termed the datum level of the sketch. When the exact altitude of the lowest point above the surface of the sea is known, the contour lines at any chosen distance apart, say 25 feet, will be enumerated from its exact height; thus if it be 200 feet above the sea, the contours will number 225, 250, 275, and so on. But where this cannot be ascertained, the lowest point is marked zero, and the contours and altitudes will only refer relatively to that point, and will be 25, 50, etc. It may be remarked that the intervals between the contours depend somewhat on the scale of the drawing. Thus with one inch to a mile they are usually 50 feet apart; from this to six inches to the mile the interval is 25 feet, and with larger scales 10 feet. In either case it is best to select one of the highest hills, and ascertain its height as carefully as possible, marking by pickets the points through which the contours will pass—that is, at 25 feet intervals above the lowest point in the sketch. This can be done with sufficient accuracy by the small clinometer before described. The observer, holding it horizontally, will note where the prolongation of the upper surface cuts the front of the hill before him, and knowing the height of his eye above the ground, he will, on walking to the point he has observed, have ascended that height above his starting-point. By repeating the operation he will gradually ascend the slope, and the position of the contour lines will be



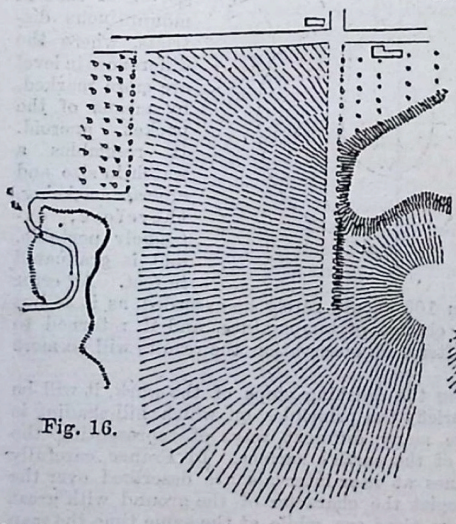
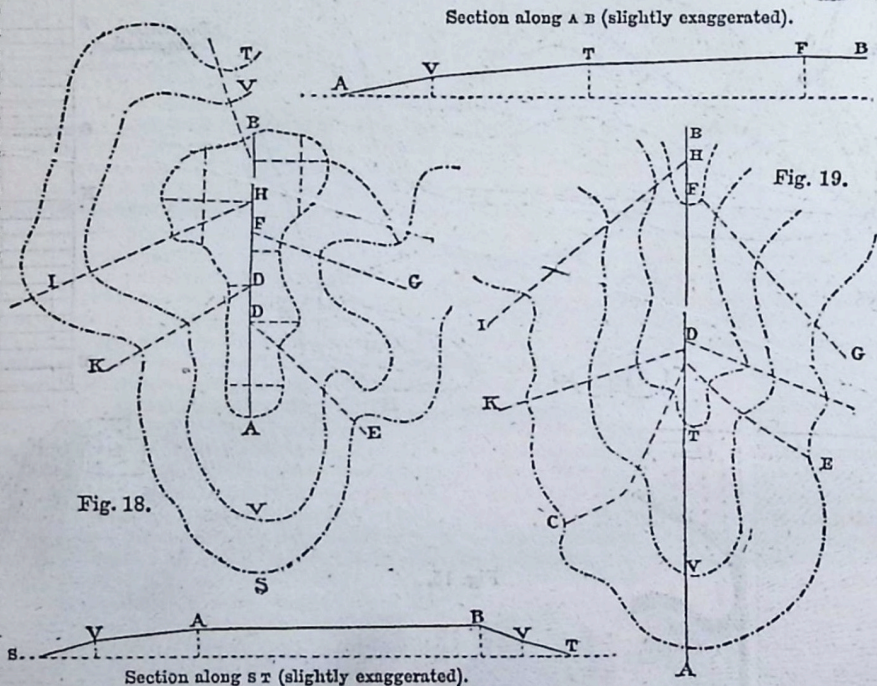


Fig. 16.

Fig. 15.

Fig. 17.

marked as he rises successively 25 feet above the datum level. Starting from any one of these points, he will direct the clinometer on all the prominent or re-entering features of the hill or range of heights, and notice such points as may appear to be on the same level, and taking the bearing of the nearest with the compass, he will measure or pace the distance to it. From this point a second level and a second bearing are observed, and the interval measured, the process being continued until the entire hill is traced. Outlying isolated hills may be on the same level as the starting-point, but being separated by valleys from the hill on which it is situated, the contour line passing through it will not, of course, be continuous with that indicating the form of the hill itself. In this instance a point on a level with one of the contours, and situated on the "outlier," is carefully observed; and then, with this as a fresh starting-point, the contour is traced around the hill by bearing and measurement, and marked with the same number as that on whose level it is. Thus, in Fig. 14, A, B, C are the starting-points of contours at 25 feet vertical interval, and their position is traced on the paper by finding the true place of A by interpolation, taking the bearing of the line A C, and measuring off on it the distance measured between the pickets A, B, C; or if the slope be very steep, tracing these measurements reduced to a horizontal plane. The picket A has been selected for the first starting-point, and thence the points D, E have been successively observed, and the intervals A D, D E measured and transferred to paper. But near F lies the hill G, and when the surveyor reached this point he noted that the tree or other object at G was on the same level; proceeding to this point, and fixing it by interpolation or by bearing and distance from F, he then completed the small continuous contour G H I, etc.



These are then numbered according to their elevation, and are traced usually in colours, either blue or red, with a dotted line. It will be noticed that when the curve is short it is considered sufficient to take bearings across the arcs, and either sketch them in by hand or pace to the distance of the farthest point of the curve from the bearing, as shown at *a b c* (Fig. 14). These levels will evidently determine the relative height of nearly all the features; but where, as at H, the hill-top lies between the contours—that is, about 55 feet high—its altitude is ascertained from any known point on the contour by levelling up by repeated operations until the summit is reached. In many cases the heights may be approximately measured by eye, and in others the angle of elevation above the lowest point may be taken by the clinometer, and the height of the hill above this be found by calculation from a table generally printed on it.*

* This table is one of natural sines, and contains two columns, one of angles from 1° to 60°, the other the decimal numbers representing the natural sines of these angles. Thus, suppose the distance of the hill-top from a known point A was either actually chained or else taken by scale from the map, and found to be 400 yards, and at the point A the angle taken by directing the top edge of the clinometer on the summit of the hill was observed to be 3°, we should look in the table for 3°, and multiply the number ·0523 opposite it by 400, which would give us 62 feet nearly as the height of the hill.

In conducting this portion of the work, as well as in traversing the roads, it is advisable to correct the position of the observer at various convenient points by taking the bearings of any of the prominent features of the triangulation and interpolating the result. This will frequently show an error in "place," especially if the line traversed or contoured be intricate, and where the time at the disposal of the surveyor is short, a large amount of useful and approximately accurate work can be done by simply fixing a series of points in this manner, and, without measuring their distance apart, sketching by eye the intermediate portions. This necessarily requires practice, but the results obtained are, when experience is gained by repeated attempts, singularly trustworthy, and, by showing the nature of the ground, are of very material assistance in filling in rapidly the shading of the hills.

The contouring glass, a simple and very portable instrument, giving very good results, may also be used for ascertaining the position of the contours. It is a small brass tube provided with a spirit-level, and a reflecting glass is so arranged that on looking through the tube the bubble of the spirit-level is seen when the tube is held horizontally. Crossed wires intersecting in the axis of the tube are fitted in the object-glass, and when the bubble is visible in the reflector, the intersection of the wires, and a point on the hill-side in the prolongation of the line of sight, are on the same level.

Altitudes may again be determined with considerable accuracy and with great saving of time in mountainous districts, where the differences in level are more marked, by means of the pocket aneroid. It resembles a watch in size and appearance, being, therefore, extremely portable, and is graduated in feet. An error of 10 or 12 feet in 100 should rarely be exceeded, as it is but little affected by change of temperature, and if returned to the same pocket after each observation the results will be more correct.

Before describing the finishing steps of the work, it will be well to examine briefly the principles on which hill-shading is based. There are many different ways of representing the physical features of the earth's surface. In France, carefully traced contour lines at near intervals are described over the area, and these depict the character of the ground with great distinctness to a practised eye, while at the same time the map is not encumbered with drawing; but it cannot convey so much information to unskilled readers as the more minute and laborious methods which depend on effects of light and shade.

There are two principal modes of expressing the nature of hill and valleys' on a plan. One, the vertical, which is largely employed in France and Prussia, and also in England, when the scale is very small and the maps are to be engraved; and in this method it is assumed that the lines represent the course which the rills of water would take in descending from the water-sheds to the lower levels. It may be used simply for expression of the ground when the relative thickness or distance of the lines apart have no especial meaning beyond depicting the folds and irregularities of the ground; or the lines and distances may be constructed according to a scale of shade, as in

German military maps, where their relative thickness denotes the *angle* of the slope as well as its form. Thus Lehman's scale of shade commences with fine lines at 5°, and proceeds in increasing thicknesses of line every 5° up to 45°, which being practically impassable is represented as composed of very thick black lines, extremely close to one another. Figs. 15 and 16 show the difference in the appearance of the two methods. Contour lines are equally useful in this as in the other kinds of drawing, but the lines or *hachures* between any two contours should not exactly coincide or be in continuation of those above or below, as too much regularity detracts from the beauty of the sketch. The work should be commenced from the crest of the hill, and in the steeper portions the lines are closer and blacker than in the plains or valleys, where the hachures become lighter and more divergent.

The advantages of this style are, that in very hilly districts, where the roads run rather across the slopes, and are of a zigzag form, they are clearly shown as they cut the hachures at an angle; and in mountainous countries, such as the Pyrenees, where the spurs and ridges are very steep and uniform, vertical lines may, perhaps, express their nature better. Again, names are printed more clearly across than between a series of lines, especially if the latter be dark. The great disadvantage is, that it does not show the relative differences of level so readily as the horizontal style.

The horizontal method (Fig. 17) may be considered as but an extension of the principle of contouring, as the space between the chief contours is filled in with horizontal lines, preserving a rough parallelism to them. These hachures are not, however, continuous, as this would tend to make the drawing too smooth and even, and destroy the irregularity of work produced by drawing them in sets or groups of various lengths, which, moreover, tends to produce a nearer resemblance to the roughness of the actual surface. The pencil should be firmly held, so as to produce an even stroke, and each set should be somewhat of a diamond pattern, the axis of which is the direction of an imaginary water-course or rivulet. Thus, in Fig. 14, the line *e f*, perpendicular to the general direction of the hachure, is the axis. As in the vertical method, the hachure may either be used to express the ground, or may give accuracy as well as expression by the use of a scale of shade. The former plan produces, perhaps, neater drawing, and admits of the display of more artistic skill, but it has the great disadvantage of want of uniformity between the work of different draughtsmen, and hence a hasty survey of a large area, subdivided between a number of surveyors conjointly, becomes an impossibility, as it cannot be put together.

The scale of shade in use in England, by military men more particularly, is that of Colonel Scott, and in this system the distance between the hachures, as well as the intensity of the line, varies with the slope, the variations occurring at 2°, 3°, 5°, 10°, 15°, 20°, 25°, 35°, beyond which the slopes are practically impassable for military movements, and the delineation is left to the skill of the draughtsman. One column in the printed "scale" is devoted to giving the number of lines which for any given slope will lie between contours 25′ apart vertically, on a scale of 6 inches to the mile; thus at 2° the horizontal equivalent for each contour—that is, the base of the triangle, of which the slope is the hypothenuse—admits of the drawing of eleven fine lines $\frac{1}{12}$th of an inch apart; at 15° four rather dark lines, $\frac{1}{30}$th of an inch apart, fill the horizontal space between two contours at that slope, and so on. This arrangement is advantageous in two ways. It admits of drawing, generally accurate save in minute irregularities that may exist between contours, being executed by the aid of contour lines only; for if the spaces in the column of horizontal equivalents are applied to the plan it is evident that the space which coincides with the distance between the contours at any point gives the number of horizontal hachures of a certain thickness and interval necessary for that angle, and hence describes the slope that lies between the contour lines. Thus, in Fig. 14, if the distances A B, B C, C K, be measured and found to agree with the spaces M N, O P, Q R, on the scale of shade, a portion of which is shown, it will only be necessary to fill in the intervals with lines of the same character as those shown in M N, O P, etc. Again, we are able to ascertain the height of any point approximately by measuring the number of lines due to a certain slope by the intervals in the column of horizontal equivalents; for if there be eleven lines of the character which expresses a slope of 2°, the difference in level between the first and last hachure will be 25 feet, since that number of lines occupies a space which is the horizontal equivalent of the slope on a scale of 6 inches to the mile; if twenty-two lines, the difference in height would be 50 feet, and so on. The disadvantage of this scale of shade is, that it is weak in the description of undulating or only slightly rising ground, and a sketch completed by it is wanting in the richness which distinguishes work executed with more attention to expression than accuracy.

Lastly, the character of the ground may be represented by washes of Indian ink, neutral tint, or sepia; but this, though excellent for rough sketches, and capable of expressing very distinctly the hills and valleys, is not susceptible of accuracy, and depends too much on the individual artistic skill of the draughtsman. In shading by "brush work" contour lines may still be used, and the only care necessary in executing it is that the washes should be laid on lightly, carefully shaded off, and the effect produced rather by repeated application of the brush than by at once endeavouring to give expression to bold features by a heavy wash of colour. The early washes should be entirely of neutral tint, and when the country is faintly marked out in this colour, Indian ink should be used for finishing the sketch, the steepest slopes being the darkest.

Whatever method be employed, it is necessary to construct some framework which shall guide the drawing. If the surface of the earth were seen from a point of view some distance above it, we should notice that the level portions would appear lightest; and since the summits of the hills are usually more or less level, and, moreover, form portions of the local water-shed of the district, it is usual to begin by describing accurately, as far as possible, the hill-crests. When the area is such that no plateau or true summit is apparent, as would be the case when the survey was conducted over a large regular spur sloping definitely in one direction, the first thing traced is the main line through it, which forms the local water-shed, and which is determined by bearings and transferred to the plan. Thus, in Fig. 19, the line A B is first marked and traversed, and from it the bearings of all the main water-course lines are determined, and set off as D C, D E, etc.; and when the ground is intricate, or when prominent spurs and ridges diverge from it, these should be further marked, and will serve as guiding lines for the hachures showing their shape.

When a plateau forms the crest of the hill, a line will be taken right through it, from a point fixed by interpolation, and its form traced by offsets (Fig. 18), and the water-course and guiding lines are delineated as before.

Having thus formed the groundwork on which the hachures can be accurately drawn, and which, from having all the main features indicated by lines, will only admit of inaccuracy in the minor irregularities of the detail, the examination of the slopes themselves must be carried on.

It would be impossible, and practically unnecessary, to test the angle of slope of every portion of the area, and it is found in practice sufficiently accurate to mark carefully down the alterations in the inclination of all the principal spurs or ridges from the summit or water-shed to the base, and leave the intermediate spaces to be filled in by eye-sketching. Thus the angles of the different portions of the spurs in Fig. 14 are carefully noted down in the following way. Commencing at the summit of the hill, the angle of the slope is taken by means of the clinometer as far as it continues uniform, and the distance to the point where the alteration occurs is paced on the guiding line. This is marked on the paper, and the space filled with small hachure lines, of the nature due to the slope, according to the scale of shade. From this point a second observation of the slope is made, the result noted down, and the distance paced as before. All the small outlying features, such as hillocks or ridges, which are not united to and form part of the main ridges and their projecting spurs, are visited in the same manner, and the details of these "under-features" sketched in.

It is advisable to make a short halt after any two adjacent spurs have been traversed, and from the one which gives the clearest view to fill in the ground lying between them: this assists the workman to complete a large section of the main features entirely before turning to the under-features, which are near it. The actual manipulation of the pencil is a matter that depends entirely on natural aptitude, and even more on constant

practice. In cases where the country is so intricate as to make it difficult to indicate whether the slopes are running up or down—as, for example, in sketching a perfectly symmetrical cone, and a perfectly symmetrical hollow of a similar shape—it is usual to denote the water-courses by a small arrow pointing towards the lower level.

In reading the work it must be remembered that the summits of the hills are left blank under ordinary circumstances, and to distinguish them from a cup-like hollow the altitudes are marked in figures on them. A blank space would also be left in drawing a saddle between two hills, and would be distinguished from the hill-top solely by the nature of the surrounding drawing.

Thus we finally have the drawing of the area completed, and it simply remains to fill in any details of houses, farm enclosures, hedge-rows, or woods, by actual traversing them with a compass and a chain. Starting-points can always be found by interpolation, and thence a series of traverses taken in different directions will provide a number of intersecting bearings which will determine the minor details. In finishing up the work much can be done by mere eye-sketching, and a number of conventional signs, altered to suit the scale of the plan, are adopted to facilitate the expression of the ground. Any particular way of delineating certain unusual characteristics that may occur can be employed so long as a reference is made to it in a column of remarks.

Nothing more remains to be done, except to draw the scale, add the names of all the places, and the direction of all the main roads—that is, whence they come, with the distance from the nearest town, and whither they lead, with the distance to the next place of importance. The directing lines which were made for the use of the prismatic compass and protractor, will give us the position of magnetic east and west, and in a convenient corner the magnetic north is indicated by an arrow, while the true north is also denoted by an arrow, inclined at an angle to it, dependent on the variation of the compass.

This may be ascertained by previously taking the magnetic bearing of a point known to be due north of the observer's position, or, if none exist, by taking the bearing of the centre of the sun as it crosses the meridian. For this it is necessary to have the instrument fitted with coloured glasses, capable of being moved over the prismatic sight, and a mirror attached to the sight-vane in which the vertical wire is fixed; but it is essential in making the observation that the compass should be horizontal, and it had better be placed on some level surface.

The time when the sun is crossing the meridian is known by referring to the Nautical Almanack on the given date, and subtracting from the known local time the difference between the sun time and mean time given in the tables.* This will give the moment, according to the local time, when the sun is on the meridian. It is evident that in northern latitudes the bearing observed will have to be subtracted from 180° to give the variation as the sun is to the south of the observer. The bearing of the pole-star may also be taken, but this is not an easy matter, on account of the difficulty of reading the compass bearing when the star is in its right position. It adds much to the value of the plan in many instances if a section of the survey on any given alignment be given. This is produced by drawing a line across the plan, as A B (Fig. 19), and measuring off on it from one end, A, the positions of the points through which the contours pass, or where any undulating alterations of level occur. A horizontal line is then traced, and these distances transferred to it, and from the points thus marked a series of vertical lines are drawn, on which are measured respectively the heights of the several points, which may be ascertained from the plan itself.

GREAT MANUFACTURES OF LITTLE THINGS.—X.

SCREWS.

BY CHARLES HIBBS.

In tracing the progress of man from savagery to civilisation, we are generally oppressed with the idea that it has been a slow, painful, and laborious journey. But here and there we come upon the record of some happy invention or discovery, which has enabled him to make a sudden start forward, and clear a great space at a bound. Such was the invention of printing, and such the successful application of the power of steam. It would seem, however, with all the boasted rapid advance of modern times, that antiquity was vastly richer in those sorts of discoveries which begin epochs, and give a new and tremendous impetus to human progress. The old discoveries seem to be of far larger importance than the new, and to have had far more influence upon the destinies of mankind. How insignificant, for instance, is the invention of printing, compared with that of written language itself—the representation by inscribed characters of the sounds of the human voice, and their reduction to an alphabet! How profitless would have been the discovery of the expansive force of steam if there had not previously been made the far greater discovery of the mechanical powers which it sets in motion—the lever, the wheel, and the screw! We might speculate curiously as to who made the first screw. The saw was reckoned so wonderful an implement that its inventor was ranked among the gods. Was the same honour awarded to the inventor of the screw? If it could have been foreseen how important and various were the offices it would be made to serve, how immensely human effort would be aided by it, there would have been no question in those days about assigning to it a superhuman origin.

The screw, as the mechanical student is of course well aware, is simply a modification of the inclined plane. A winding road round a hill, or a winding stair by which the summit of a tower is reached, will be familiar illustrations of this fact. A common wood screw enters a piece of wood in the manner of a wedge, or movable inclined plane, with the difference that it acts in a circular instead of in a direct line. When a lever is connected with the shaft of the screw, as in an ordinary vice-pin, there is a combination of two powers; and when weights are affixed, as in the loaded arms of a fly-press, there is the addition of momentum, which together produce an almost irresistible force. These considerations belong rather to the abstract science of mechanics than to the subject of these papers, which treat principally of manufactures; but may be usefully alluded to here as illustrating the principles which should guide production.

If a strip of paper be wound round a shaft of wood—say a lead pencil—at an angle, it will be found that its edges fall into a position resembling the threads of a screw. This was, indeed, the method formerly used for originating the large screws used in machinery. A piece of paper was cut into the shape of an inclined plane, *i.e.*, a right-angled triangle, the height of which corresponded to the length of the shaft of the intended screw, and the hypothenuse to the inclination or pitch of its threads. This was wrapped round tightly and pasted to the shaft, and a nick made with a file along the spiral line formed by its edge, the indentation being afterwards deepened until from the incipient worm a nut could be formed, which served as a holder or guide for the cutters that were to complete it. After the pattern screw was made any number of copies could be produced from it, by processes we have yet to describe; but it was often a matter of importance to get a true thread of a new size or pattern, and many were the contrivances adopted for the purpose. A workman at Soho employed the following modification of the paper method:—He first of all turned his cylindrical shaft perfectly true, and then cut a strip of paper of the same length, whose width would just encircle the shaft when pasted round it, the edges coming together accurately. Before pasting it on he had marked it with a series of diagonal lines, drawing them from points made by compasses along the sides at intervals equal to the distance which one thread of the screw was intended to traverse. When it was cemented to the shaft, these lines ran into each other and formed a continuous thread, along which he made a series of indentations in the metal by means of a centre punch and a hammer, afterwards connecting them with a file. We may readily conceive that this method would admit of greater nicety of manipulation than the last, because there would be only one thickness of paper to cut through before reaching the iron. When he had produced a roughly-formed thread, he suspended the shaft in a box properly contrived, and cast round a portion of it a block of lead, the impressions in which served as cutter guides. A ruder method was to wind a piece of iron wire obliquely round the shaft, and form a mould from it by compression, with the same object of getting a guide for the cutters. A more

* Under the head of "Equation of Time."

scientifically elaborate, though still primitive, method of originating screws is described in the *Philosophical Transactions.* Two straight edges are fixed parallel to each other upon a table, the distance between them being exactly equal to the length of the screw-shaft. Their own length must be equal to as many circumferences of the shaft as the thread is intended to traverse it, which depends, of course, upon whether the screw is intended to have a slow or a quick pitch. Thus, if the screw is to advance one inch in a complete revolution, and the shaft be ten inches long, the length of the parallel straight edges must be ten circumferences of the shaft. A third straight edge is now fixed diagonally between the other two from end to end, and its angle in that position is precisely that of the thread proposed to be made. In the upper edge of this cross-piece a groove has been cut, and a strip of Bristol board inserted, which is smeared with printers' ink. The smooth shaft is now made to roll evenly between the parallel uprights, over the diagonal, which prints upon it a regular spiral line, which the workman can follow with his tools. As the mechanical arts advanced it became easy to cut a correct thread in a lathe, without any guides or previous marking, the only requirements being that the cutter should be fixed at the proper angle, and that its rectilinear motion along the shaft should bear the same relation to its revolution as the pitch of the thread does to its circumference. Beautiful screw-cutting lathes are now constructed, in which, by the substitution of wheels of different radii, these relative motions can be so adjusted as to cut threads of any pitch upon shafts of almost any size.

From screws of moderate dimensions plates or dies can be formed, which will in turn cut other screws, and so on, *ad infinitum.* The way in which an interior screw can be made is by converting the original screw into a tap, which may be effected in various ways. It may be done by filing down the point of the screw into a taper square, leaving just a small portion of the thread upon the corners. This leaves obtuse angles, which are not of much use for cutting, but which serve well enough for some kinds of work. If it is filed of a triangular shape, the angles will have more cutting power; but they are still too obtuse to take out the substance of the metal. Or the tap may be filed away to a half-circle, in which case a radial angle is obtained, the sharpest that is ordinarily consistent with safety. Generally, taps are in succession used consisting of all these various forms, or with the addition of others nicked across the thread, the first having the threads blunted or left shallow, and the later ones coming up gradually to a sharp and perfect worm. The metal to be operated upon is held firmly in a vice or other machine, and the taps, fixed in a wrench of some kind, are worked backwards and forwards until the interior screw is a reverse fac-simile of the exterior one, plenty of oil being used to facilitate the process. If the whole substance of the metal were cut out from the hollows of the thread of the interior screw, the hole made to receive the tap in the first instance should be exactly the diameter of the inferior shaft, *i.e.*, the external screw stripped of its thread; but as part of the worm has to be formed by compression, and as some portion of the solid metal will be forced into the hollows of the tap, the hole must be made a trifle larger to allow of it. It is from neglect of these precautions that workmen get what is called a "slip-screw," viz., one in which the threads do not bite, and the screw turns round in its receptacle; if the hole has been bored too small the tap will not enter readily, or progress in proportion to its work, and blurs or strips the thread as it makes it; while if it be bored too large the thread made is too shallow, and is mainly formed by the burr of the metal, which will have no holding power. Pins with external screws are made with screw-plates, or dies, in the reverse manner to that just described, a portion of the thread being cut away to form a cutting or compressing surface, and a series, gradually deepening, being generally used. Dies are in two, three, or more pieces, being fixed in stocks, and tightened up with screws as the work advances. It need scarcely be remarked that the cutting instrument, whichever it may be, is hard, and the metal to be operated upon is soft. Innumerable are the uses for metal screws, from the minute pins, scarcely visible to the naked eye, which are used in watch-making, to the massive bolts which hold together the parts of our largest men-of-war.

Wood screws, by which are meant iron screws to screw into wood, are made in immense quantities, and are daily coming into more general use as a substitute for nails. In some parts of Scotland they are called "screw-nails," and it is worthy of remark that the screwed pins used in military small-arms are still, in the antiquated phraseology of the War Office, called "nails." Wood screws used to be made by a process which was primitive enough. The blanks were forged by the nail-makers, and resembled that species of nail called "counter-clout," with a blunt end. The transverse nick, or slit, was cut by a hand-saw in a vice, and the worm was filed laboriously out by hand. Later on they were wormed by means of a simple hand machine constructed as follows:—A spindle, with a "chuck" to hold the screw, worked in a frame fixed upon a bench, the back part being fitted with a winch. In front were a pair of cutting dies, upper and lower, the lower one being a fixture, and the other lying upon it heavily weighted. By means of a lever pressed down by the foot, the workman raised the upper die a little to allow the point of the screw to enter, and then, releasing the weight, turned his winch backwards and forwards until the thread was cut deep enough. The work, though very hard, was frequently performed by women, who bore the contemptuous designation of "screw-girders."

About the year 1849 machinery for making screws began to be extensively worked by steam power. It was the invention of a German, named Colbert, a clock-maker, and, compared with the clumsy methods formerly in use, must have been regarded as a remarkable step in advance. The screw-blanks were now made from iron wire, drawn of the required thickness, and cut off from the coil by a machine, which at the same time punched up the end to form the head. The half-formed screws were then turned one by one in a lathe, and cutters of the required form finished off the heads neatly. The next process was to nick the heads, which was also done by a machine. There were many different forms of nicking machines in use at various manufactories; but in principle they did not differ greatly, and the following description may serve to convey an idea of their generic type:—A small iron barrel or cylinder revolved slowly, overhung by a series of fine-cut circular saws, which revolved very rapidly, the motion of the saws and the barrel being in opposite directions. The surface of the barrel was pierced with a number of small holes, in lines running round the circumference immediately under the saws. The screw-blanks were fed into the holes, either by hand or by a self-acting feeding machine; and as they were carried round by the cylinder each head came under a saw, and was nicked across the centre, the blanks falling out afterwards by their own weight. They were then taken to the worming machine, which was thus constructed:—In front were a pair of holding clamps, which could be opened by the touch of a lever, and which gripped the head of the screw tightly, being assisted thereto by a small interior chisel which entered the slit. The driving-band being now slipped from the loose pulley to the tight one, the screw-shaft began to revolve, and at the same instant two other actions of the machine were brought into play. The spindle which carried the blank was furnished at its hinder end with a regulating screw the size and pitch of the one intended to be cut, and a nut being engaged with this carried the spindle forward at the same time it was revolving. Simultaneously, a cutting instrument came into contact with the shaft of the screw, and cut upon it a worm identical with that on the regulating screw behind. The machine having a reversible motion, this process was continued backwards and forwards, until the thread was perfect.

The screws made by this machinery were immensely superior to those formed in the old-fashioned compressing dies, which could not make a thread of sufficient depth, and a little force would suffice to "draw" them if the wood were at all soft. Still, the new screws were defective, inasmuch as they were not pointed or gimlet-ended, and, consequently, would not enter readily; and there was a burr left at the hinder end of the thread which "ragged" the wood. A beautiful screw was introduced and patented by Mr. Nettlefold, in which all these defects were avoided, and many new advantages secured. The shaft was tapering and pointed at the end; the thread was deep and bold, the under side having as great an inclination as could be given to it, while the upper side was almost flat. This enabled the screw to penetrate the wood easily, and at the same time to resist almost any force tending to draw it out.

The screw-making plant just described has been altogether

superseded by machinery introduced into this country from the United States about eighteen years ago. In the "Patent Records" of that time we find the following description in a specification lodged by a firm of manufacturers from Rhode Island:—"This invention consists of a peculiar arrangement or combination of parts into a machine for cutting wood screws, for which purpose a series of holders or revolving spindles, suitable for holding revolving screw-blanks, are used. These spindles or holders are placed and revolve at a tangent to the periphery of a circulating rotating tool, which carries numerous cutters, and by reason of there being a cam or guiding track for the cutters, they are engaged as they come opposite a screw-blank, to be moved outwards, and to make a cut across the revolving screw-blank. Each cutter, after making its cut, is moved back out of action till it comes to the next screw-blank; it is then moved outwards to make its cut, and so on continually; the succeeding cutter being protruded further out than the preceding one, cuts more and more deeply into the screw-blank. The cutting point or edge of each of the succeeding cutters is wider than the preceding one, and therefore cuts wider and wider as well as deeper and deeper into the screw-blank carried by the holders. It will be evident that by thus using several cutters in the same rotating tool, several revolving holders may be used, each carrying a screw-blank in the presence of the rotating tool, and have the separate cutters act in succession on each screw-blank."

Here for the present we must leave this interesting subject, but in a future paper we shall describe the effect which the introduction of the American machinery had on the screw trade, and give additional particulars respecting this important manufacture.

NOTABLE INVENTIONS AND INVENTORS.

XXIV.—CHLOROFORM (*continued*).

BY JOHN TIMBS.

The action of ether, and the best mode of administering its vapour, was investigated by Dr. John Snow, who in September, 1849, published a work on "The Inhalation of the Vapour of Ether." This subject was investigated with great success in Edinburgh, and led to the discovery by Dr. Simpson, of that city, of chloroform, a terchloride of formyle, which acted more speedily and effectively. From this time chloroform became more generally employed for the production of artificial anæsthesia. The general effects of chloroform resemble closely those of ether. It is a more potent remedy, and produces anæsthesia more rapidly and certainly than ether.

Chloroform was first discovered and described at nearly the same time by Soubeiran, 1831, and Liebig, 1832; its composition was first accurately ascertained by the distinguished French chemist Dumas, in 1835. It had previously been used by some practitioners internally. Guillot prescribed it as an anti-spasmodic in asthma, in small doses, and diluted 100 times. But no person, Dr. Simpson believes, had used it by inhalation, or discovered its remarkable anæsthetic properties, till the date of his own experiments. It is a dense, limpid, colourless liquid, readily evaporating, and possessing an agreeable, fragrant, fruit-like odour, and a saccharine, pleasant taste.

In March, 1847, M. Flourens caused animals to inhale pure chloroform, which rendered them insensible; but, believing it to be a dangerous agent, he did not think of commending it for the prevention of human pain. Dr. Chapman says, "Anæsthetic agents should only be administered by those who possess knowledge and experience of their properties. The very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death; only those agents which are capable of leading us along this solemn path, and which having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain."

As an inhaled anæsthetic agent, chloroform possesses over sulphuric ether the following advantages:—1. A greatly less quantity of chloroform than of ether is requisite to produce the anæsthetic effect. 2. Its action is much more rapid and complete, and generally more persistent. 3. The inhalation and influence of chloroform are far more agreeable and pleasant than those of ether. 4. The use of chloroform is less expensive than that of ether. 5. Its perfume is not unpleasant, nor does it exhale in a disagreeable form from the lungs of the patient, as generally happens with sulphuric ether. 6. Being required in much less quantity, it is much more portable and transmissible than sulphuric ether. 7. No special kind of inhaler or instrument is necessary for its exhibition. A little of the liquid diffused upon the interior of a hollow-shaped sponge, or on a pocket-handkerchief, or a piece of linen or paper, or held over the mouth and nostrils, so as to be fully inhaled, generally suffices, in about a minute or two, to produce the desired effect.

"The following is the chemical constitution of chloroform:—Formyle is the hypothetical radical of formic acid, first discovered in the red ant (*Formica rufa*), and hence named. It is now obtained from starch, sugar, and, indeed, from most other vegetable substances. A series of chlorides of formyle are produced when the hypochlorites are brought to act on the chloride, oxide, and hydrated oxide of methyle (pyrolixic or wood spirit). In the same way, as formic acid may be artificially procured from substances which do not contain formyle ready formed, so also are the chlorides of this radical capable of being procured from substances which do not originally contain it.

"Chloroform, chloroformyle, or the perchloride of formyle, may be made and obtained artificially by various processes—as by making milk of lime, or an aqueous solution of caustic alkali act upon chloral—by distilling alcohol, pyroxylic spirit, or acetone, with chloride of lime—by leading a stream of chlorine gas into a solution of caustic potass in spirits of wine, etc. The resulting perchloride of formyle consists of two atoms of carbon, one of hydrogen, and three of chlorine.

"It is now well ascertained that three compound chemical bodies possess, when inhaled into the lungs, the power of superinducing a state of anæsthesia, or insensibility to pain in surgical operations, etc.—namely, nitrous oxide, sulphuric ether, and perchloride of formyle. These agents are entirely different from each other in their chemical constitution; hence their elementary composition affords no apparent clue to the explanation of their anæsthetic properties." (Dr., afterwards Sir James Simpson.)

Dumas, in his examination of chloroform, showed that if for the three equivalents of oxygen three equivalents of chlorine were substituted, the product would be a *terchloride of formyle*. Such being Dumas's ingenious view of the constitution of this important substance, he very properly named it *chloroform*.

This substance is prepared, according to the Pharmacopeia of the London College of Physicians, as follows:—"Take of chlorinated lime, 4lb.; rectified spirit, 0ss.; water, 0x.; chloride of calcium, broken into pieces, 3j. Put the chlorinated lime, first mixed with water, into a retort, and then add the spirit, so that the mixture may fill only a third part of the retort. It is then heated in a sand-bath, and as soon as ebullition begins, the heat is withdrawn. The liquid is then distilled into a glass receiver. A quart of water is then added to the distilled liquid, and well shaken. The heavier portion, which subsides, is then separated, and the chloride of calcium added to it, and frequently shaken for an hour. The liquid, which is the chloroform, is again distilled from a glass retort into a glass receiver. It is a transparent, colourless liquid, having a specific gravity of 1·48. It has a fragrant, apple-like smell, and a slightly acid and sweet taste. It is soluble in alcohol and ether, but requires 2,000 parts of water for its solution. It dissolves camphor, Indian rubber, wax, and resins. It is not inflamable. This substance is sometimes given internally, in doses of from five to ten minims, and acts as a stimulant, sedative, and anti-spasmodic and anæsthetic."

Sir James Simpson's special application of the new remedy in child-birth must next be noticed. In early days it was believed that the period of insensibility could not be prolonged with safety. This erroneous belief was speedily dispelled by Simpson, whose most profound compassion had been excited by the sufferings of women in child-birth. These sufferings he determined, if it were possible, to relieve, and on the 19th of January, 1847, he, for the first time, employed ether for this purpose, and with complete success, in a case of unusual difficulty and severity. Others of like kind followed, and in March he published his first memoirs on the subject. From this time his use of ether in natural labour commenced, and in November, 1847, he announced that he had employed it, "with few and rare exceptions," for every patient he had attended.

"And I have no doubt whatever," he adds, "that some years hence the practice will be general. Obstetricians may oppose it, but I believe our patients themselves will force the use of it on the profession. I have never had the pleasure of watching over a series of better and more rapid recoveries, nor once witnessed any disagreeable result follow to mother or child, while I have now seen an immense amount of maternal pain and agony saved by its employment. And I most conscientiously believe that the proud mission of the physician is distinctly twofold—namely, to alleviate human suffering as well as to preserve human life."

"While announcing these successes, Simpson had, nevertheless, been struck by certain inconveniences connected with the use of ether, and by the idea that its anæsthetic properties were probably common to many substances of a similar kind, some of which might offer still greater advantages. He made inquiry among his chemical friends with regard to such agents, and selected several for experiments, in which he was zealously seconded by his assistants, Dr. Keith and Dr. Duncan. In such experiments it was Simpson's custom first to test the safety of a new vapour by inhaling it himself, and then to observe its effects by administering it to his assistants. Mr. Waldie had suggested that the perchloride of formyle might be worthy of a trial; and in the application of this agent, soon and since universally known as chloroform, Dr. Simpson made the great discovery of his life. His work was very materially promoted by the highest personage in the land, who, having sent for him and heard his opinions, and the results of his experience, retained Dr. Snow to officiate as chloroformist at her then pending accouchement. One Edinburgh damsel, when the example set by Her Majesty became known, is said to have expressed much surprise that the new pain-destroyer 'should hae gotten sae far sooth as London;' but the example, nevertheless, had great weight, and every fresh convert served to spread conviction in ever-widening circles. For many years the use of chloroform has been as customary with the accoucheur as with the surgeon, and it would now be more remarkable that it should be withheld than it should be administered." (Review of Sir James Y. Simpson's Work, *Times*, May, 1872.)

The physiological effects of the vapours of ether and chloroform are classified by Professor Brande in five definite and progressive stages. 1. In the first stage, which is transient, the patient is exhilarated, but conscious of what is passing before him, able to direct the motions of his limbs, and sensitive to pain. 2. In the second stage, mental functions as well as voluntary movements are performed, but irregularly. The patient knows not where he is, and is generally, but not always, ready to do what he is directed. This, according to Dr. Snow, who has investigated the whole subject with great accuracy, is the stage of dreams. 3. It is in the third stage that the mental functions and voluntary movements become dormant, although external impressions may here produce involuntary action. Any pain inflicted in this stage might call forth a groan, but it would be expressed by articulate words. 4. In the fourth stage there is no movement besides that occasioned by the snoring of the patient, which indicates him to be in a condition of absolute insensibility. 5. In the fifth stage, which has been witnessed only in the inferior animals, the breathing becomes laboured and irregular, involuntary and voluntary muscles are alike powerless, respiration and circulation successively cease, and death ensues.

The fatal effects of chloroform depend not upon peculiarities in individual constitution, but upon faults in the mode of administration.

Dr. Phipson states of the action of chloroform: "In the human body exist different systems of nerves, and the art of producing anæsthesia consists in allowing one system to work as usual, while the other systems are under the influence of sleep. The nerves of motion and sensibility are made to sleep, while the nerves of organic life continue their functions. We are now enabled to appreciate these wonderful discoveries, and to admire the marvellous arrangement of the nervous system. The problem of depriving man of sensibility and motion without impeding respiration, circulation, digestion, or, in other terms, of depriving him of the means of his faculty of moving and of feeling pain without depriving him of life, has been solved. During anæsthesia (the sleep of chloroform) man lives like a plant: his animal functions are taken from him for a time."

Dr. Chapman considers that we have no expectation that any agent of anæsthesia will ever be discovered which may be used by ignorant, inexperienced, or incautious persons. We may again repeat that "the very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death; and only those agents which are capable of leading us along this solemn path, and which having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain." This consideration should teach us that these beneficial agents, like that of fire, cannot be recklessly used with impunity, and that only those who possess knowledge and experience of their properties and modes of action are justified in administering them.

Lastly, chloroform has been extensively used in every hospital in Europe. It was the greatest boon to our poor wounded in the Crimea and India. The exhaustion of the stock of chloroform in Lucknow was one of the greatest calamities in that fearful siege. No fatal case occurred from its frequent use in the Crimea. Dr. Snow could ascertain but fifty fatal cases throughout the world which could fairly be attributed to chloroform during ten years. For several years before his death he made about £1,000 a year for administering chloroform in private practice. He met with but one fatal case among the many thousands to whom he administered chloroform. The fatal effect is by paralysing the heart; but the chance of this result, with due care, is very small; indeed, it has been compared with the chance of a fatal railway accident.

WEAPONS OF WAR.—XIV.

BY AN OFFICER OF THE ROYAL ARTILLERY.

RIFLED PROJECTILES.

In immediate connection with the preceding chapter (Vol. II. page 391), is the subject of rifled projectiles. The subject is not only a very important but a very wide one—so wide, indeed, that we despair of doing justice to it within the limits which must necessarily be observed in a series of papers of this description. As to its importance, that must be evident to the most superficial observer. A gun, after all, is only the means of application of its projectile. It is the motive power of the machine, not the machine itself—it is the projectile which strikes and does the work. Therefore, upon the suitability of the projectile for the end for which it is designed, depends ultimately the value of the gun. Even the "Woolwich infant" firing snowballs, or discharging cast-iron shot against an armour-plated vessel, would accomplish nothing. And so the ultimate virtue—the effective value—of the gun resides in the projectile, by which the destruction to life or material is wrought.

To attempt even to enumerate within a single chapter the varieties of rifled projectiles in the service would be vain. In the case of smooth-bore projectiles, where the sphere is the only practicable form,* and where there are no changes to be rung on modes of rifling, the classification is comparatively easy. But with rifled projectiles, we have not only the shot or the shell, each with its varieties, but we have of each the breech-loading and the muzzle-loading type, as well as infinite varieties of form and proportion.

Breech-loading projectiles, although they exist in great numbers in our service, are gradually disappearing before the more simple, less expensive, but not less efficient, muzzle-loading projectiles. As has been already explained in preceding chapters, the breech-loading projectiles in use in the English service are of a construction suggested by Sir William Armstrong—viz., an iron projectile covered with a leaden coating, slightly larger than the bore, which on the explosion of the charge becomes forced into the shallow grooves of the rifling, thus communicating the required rotatory motion to the shot. It should be clearly understood that the lead coating is merely a means of spinning the projectile. It is not an essential or integral part of the projectile—that is to say, breech-loading projectiles can be spun by other means than a lead coating, although this lead coating may, and does in fact, cover an infinite variety of constructions of projectile. Some of the salient advantages and disadvantages of this *système forcé* have already been

* Except in the case of such exceptional projectiles as the smoke ball and Manby's shot.

mentioned in a former chapter. To discuss this branch of the question as it merits is impossible here. Suffice it to say that a series of experiments, carried out almost without intermission, and by all sorts of committees, since 1858, has ultimately resulted in the decided preference of studded to lead-coated projectiles for our service. Gradually projectiles of the latter type will disappear; and although other nations, such as the Germans, appear to cling to them, it is not improbable that fuller experimental inquiry will tend to the same conclusions as those at which we have arrived. The normal type of rifled projectile in our service is now a muzzle-loader, the spin being given to the projectile by means of studs, set on so as to suit either a uniform or an "increasing" spiral, according to the rifling of the gun. The material of the studs, their size and strength, are proportioned to the strain which they will have to bear. They are made either of copper or of gun metal (copper and tin), and are attached to the projectiles by means of "undercutting."

Passing from the means of spinning the projectile to the projectile itself, we find several varieties, according to the nature of the work required to be accomplished. The simplest form of rifled projectile is the shot. Of this there are two or three principal types — the ordinary solid shot, the case-shot, and the Palliser shot. The ordinary solid shot, which is an elongated cylindro-conoidal projectile of cast iron, about 2½ calibres in length, is comparatively little used now. It is of no use against an armour-plated vessel, while against a wooden vessel, or against inflammable material of any description, a shell is much more effective. Therefore ordinary solid shot are used chiefly for practice, as being the cheapest form of rifled projectile available for the purpose. The case-shot differ from those used with smooth-bore guns only in detail. They are provided with segmental zinc linings, to prevent the crushing up of the case into the grooves of the rifling. Some patterns have coal dust between the balls, others sand and clay, to prevent the agglomeration of the balls, or their loss of form on discharge. For short ranges against the *personnel* of an enemy a case-shot is the most effective projectile known to artillerists. But this effect, on account of the lightness of the balls, and their rapid dispersion, is soon lost, and then the shrapnel shell comes into play. Of the smooth-bore shrapnel we have already spoken; of the rifled shrapnel we shall speak directly.

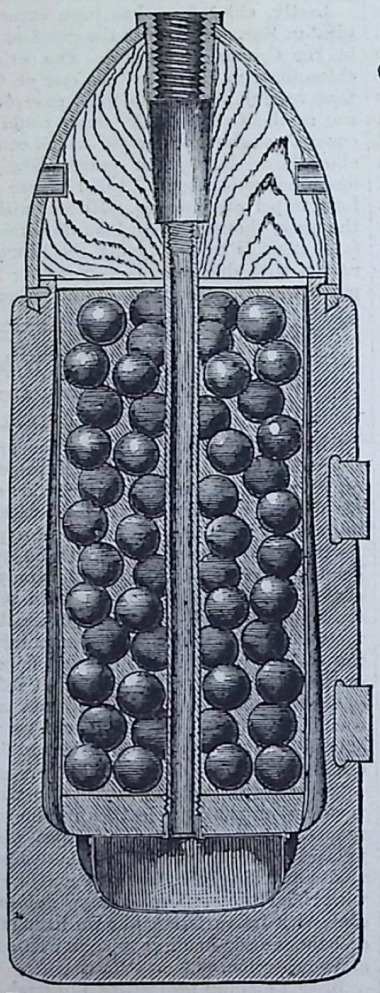


Fig. 1.—RIFLED SHRAPNEL SHELL (SECTION).

A more important projectile for the larger rifled guns is the Palliser shot. This may be considered the projectile *par excellence* of our heavier or plate-piercing guns. The Palliser shot is called after its inventor, Major William Palliser. This distingushed officer, who, though not an artilleryman, has done much to improve our artillery material, has the merit of having, in his shot, as in other of his inventions, struck out an original line of his own. At the time when Major Palliser introduced his shot efforts were being made to find some material suitable for piercing iron plates. The choice seemed to lie between a tough steel and a hard wrought iron. It was generally thought at that time that toughness was one of the elements necessary to success. And this combination of hardness and toughness was exceedingly difficult to obtain, at anything like a reasonable cost and with uniformity. Major Palliser may lay claim to originating the idea that toughness was not necessary at all. All that was wanted, he said, was hardness—hardness intense and unvarying; and this he found, allied with cheapness, in ordinary "chilled" iron—in iron, that is to say, which had been cast in an iron mould or "chill"* instead of in sand. Great care was necessary in the selection of the iron, and innumerable experiments were made on this point in the Royal Laboratory. Indeed, even Major Palliser's genius would have availed little without the indefatigable and zealous co-operation of the able manager of that department, Mr. Davidson, who, under Colonel Boxer, laboured for years at this important subject. At last a suitable iron was found, and the appliances for casting these shot were brought, under Mr. Davidson's guidance, to great perfection. It must not be supposed, however, that hardness is the only feature in Major Palliser's projectiles. On the contrary, that hardness had to be associated with a particular form of shot to produce any useful results. A flat-headed or an obtuse-headed chilled shot shivers to pieces like so much glass on the side of an iron plate. Major Palliser had got the hardness, but with it he had got brittleness. How was this brittleness to be neutralised or eliminated? Up to that time it had been supposed that it could be got rid of only by introducing some toughening element. But, as we have stated, Major Palliser chose another course. He argued that if he could make his shot of such a form that it would convert the shock of impact into a gradually increasing pressure, he would neutralise the brittleness. He applied this principle by adopting an ogival head, with a radius of from 1¼ to 1½.

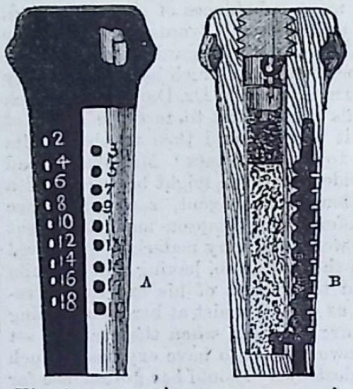


Fig. 2.—BOXER'S NINE SECONDS' TIME FUSE.
A, fuse; B, section of fuse.

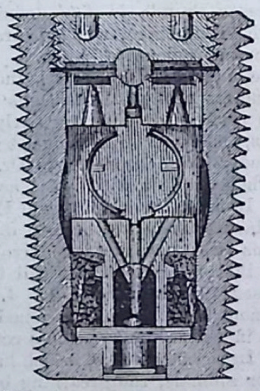


Fig. 3.—PETTMAN'S PERCUSSION FUSE.

Thus the Palliser projectile is not merely a chilled iron projectile—for that would constitute in itself no novelty, although chilled iron had never before been applied to the penetration of armour plates—nor is it merely a sharp-pointed ogival-headed projectile. It is a combination of material and form, and in this combination the virtue of the discovery resides. Indeed, we believe that Major Palliser lays no particular stress on the chilling, except as a convenient and inexpensive means to an end. Any hard, white metal shot, made

* At one time *all* shot were cast in this way.

with a Palliser head, would answer the purpose; in fact, some successful experiments have been made with white iron shot of the Palliser form, the shot having been cast in sand and not in chill. A few words should here be said as to the meaning and effect of chilling. The meaning of chilling is casting iron in an iron mould instead of in sand. The result of such casting is that the metal, instead of being slowly cooled, is quickly cooled, or "chilled," by being brought into contact with a material of high conducting power. In proportion as the cooling is slowly or quickly effected so does the separation of the carbon from the iron proceed more or less completely, quick cooling being unfavourable to such separation. In proportion as the separation is complete, so will the iron assume a greyer or darker tint, in consequence of the mechanical diffusion through it of the particles of carbon in the form of graphite; while, conversely, in proportion as the separation is incomplete—in other words, in proportion as the cooling is rapid—so will the iron assume a more or less brilliantly white appearance, the carbon being held in chemical combination with the iron. White iron, as compared with grey iron, is intensely hard and brittle; and Major Palliser's process consists in converting into this hard and brittle material iron which is primarily neither one nor the other—viz., grey or mottled iron. The result, when cast into ogival-headed projectiles, is extraordinarily effective. At comparatively small cost a shot is obtained with which no steel projectile has yet been able to compete, and the effect of these shots breaking up after they have penetrated, and entering the vessel in a shower of splinters, is equal to that of a shell or of a case. At first Palliser projectiles were cast entirely in chill, but it was subsequently found desirable to cast the bodies in sand (so as to avoid exposing too brittle a portion to the shock of discharge), and the head only in chill (so as to obtain the necessary penetrative results). Palliser shell differ from Palliser shot only in having a powder-chamber for the bursting charge in the centre. For manufacturing reasons, which need not be here entered into, the shot are now cast with a small cylindrical hollow or "core" in the centre, but the shells have a much larger hollow, and contain from 2 to 15 lb. of powder, according to their size. The explosion of the powder is effected by the breaking up of the shell on impact on iron plates, no fuse being required. This effects a considerable simplification in the use of these projectiles. The Palliser shell is shown in Fig. 5.

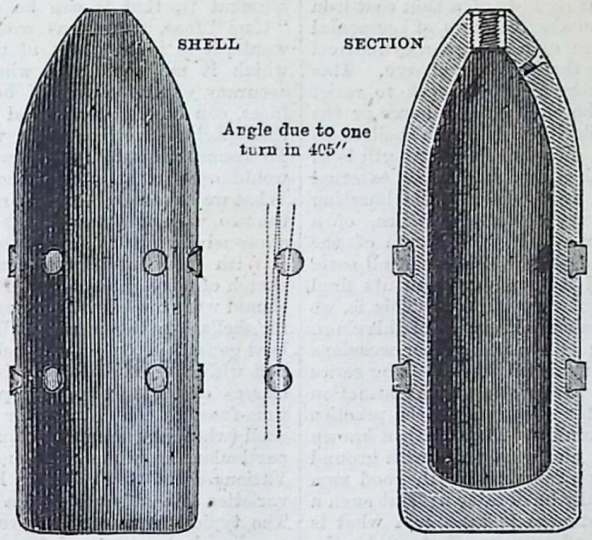


Fig. 4.—NINE-INCH MUZZLE-LOADING COMMON RIFLED SHELL.

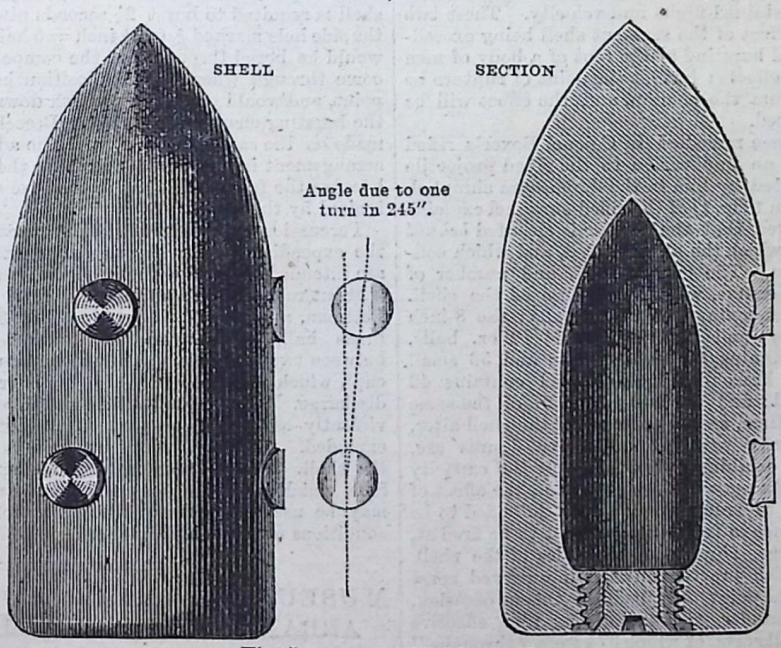


Fig. 5.—THE PALLISER SHELL.

In addition to Palliser shell and shot, our rifled guns fire common and shrapnel shell, and some of the smaller natures fire segment shell, which latter, however, are gradually giving place to shrapnel. A few remarks must now be made on each of these projectiles. The common rifled shell (Fig. 4) is a cylindro-conoidal projectile of cast iron, which is exploded by means of a fuse (either "time" or "percussion") fitted into its apex. The length of the 12-inch shell is about 30 inches, that of the 7-inch about 22 inches, or, roughly, from $2\frac{1}{2}$ to $2\frac{3}{4}$ times their calibre. In the case of the 10-inch shell the proportion is greater, that projectile being 32 inches (or over three times its diameter) in length. The capacity of some of the larger shells is enormous. Thus, the 12-inch shell takes no less than 35 lb. of powder, the 10-inch shell takes 26 lb., the 9-inch 18 lb., the 8-inch 13 lb., and the 7-inch 8 lb. For use at short ranges the 7-inch gun is also provided with a "double" shell—*i.e.*, a longer projectile of increased capacity. This shell contains nearly 13 lb. of powder. It is instructive, as conveying an idea of the enormous increase of shell power due to the use of elongated projectiles, to compare the above-mentioned bursting charges with those of the old smooth-bore spherical shell. Thus—

Rifled.	*Smooth.*	*Rifled.*	*Smooth.*	*Rifled.*	*Smooth.*
13-inch, 32 lb.	10 lb.	10-inch, 26 lb.	5 lb.	8-inch, 13 lb.	$2\frac{3}{4}$ lb.

For use against wooden ships one rifled shell would be as powerful as many smooth-bore shells; and when the greater range and accuracy of the former are taken into consideration, it will be evident that the importance of the introduction of rifled projectiles as a means of destruction can hardly be overrated. They deal destruction at greater distances, in a larger degree, and with increased certainty. Against iron-plated vessels common shells have comparatively little value, on account of their low penetrative power. But if the ship is only very lightly plated, or not plated at all, one rifled common shell may cause her destruction. The moral effect of the explosion of from 20 to 30 lb. of powder inside a vessel is incalculable. We believe that it is a fact that the defeat of the *Alabama* by the *Kearsage* was practically completed by a single shell. In the smaller guns common shells are very useful against an enemy's earthworks, houses, and material generally. By some nations (as the Germans) they are largely, almost exclusively, used against his *personnel*. But such a use seems hardly suitable for common shell; at any rate, greater destruction can be effected in an enemy's ranks by means of shrapnel and segment, and the Germans have, since the late war, taken

steps to introduce shells of the shrapnel—or, as we should say, *man-killing*—type.

Before speaking of the rifled shrapnel shell, it may be well to explain the construction of the segment shell. This projectile, which is now gradually dying out of our service, was the invention of Sir William Armstrong. It consists of a thin cast-iron shell, inside which are built up a number of rows of segmental pieces of iron, like stones in the arch of a bridge, a cylindrical cavity being left up the centre for the bursting charge. This construction gives the projectile very great strength to resist external pressure, whether from the shock of discharge or the shock of impact, or otherwise, while it enables the shell to be opened by a small bursting charge. The internal strength is to the external as the internal strength of an arch is to its external strength. Then, when the shell is opened by the bursting charge, the segments form so many separate missiles, of a formidable and destructive character. In the course of the trials at Dartmoor, in 1869, no less than 1,194 hits of all sorts were obtained with 15 rounds of 12-pounder segments fired against a column of six rows of infantry targets. This is, we believe, the greatest effect ever obtained with shells of this class, and to this extent it is exceptional; but on many other occasions the segment shell has greatly distinguished itself. Long series of experiments have, however, gone to show that such distinction is likely to be achieved only when the conditions of the practice are peculiarly or accidentally favourable. Thus, with a known range, at a column of troops, with plenty of time, with ground especially favourable for percussion fuses, and with good men to lay the gun, excellent results may be obtained. But such a combination of favouring circumstances is rare, and what is wanted is a shell which will give good average effects under the ordinary conditions of service. This the segment does not do, and cannot do, for two very good reasons:—(1) the bursting powder being in the centre of the shell, it necessarily causes great lateral dispersion of the segments in opening the bullets; (2) the segments being made of iron, which, as compared with lead, has a low specific gravity, and being of an irregular form, are not favourable to sustained flight and velocity. These two conditions result in the effect of the segment shell being exceedingly local. A good shell bursting at the foot of a body of men will produce tremendous effects; but let the point of rupture be twenty or thirty yards from the column, and the effect will be at once enormously reduced.

These defects have been remedied in Colonel Boxer's rifled shrapnel shell, which is an application to the rifled projectile of the construction adopted by him in the diaphragm shrapnel. The accompanying section (Fig. 1) of the rifled shrapnel explains itself. It will be observed that the powder is situated *behind* the missile matter, with which the shell is filled, and which consists of spherical bullets. The size, weight, and number of these bullets varies, of course, with the calibre of the shell. Thus, the 7-inch shrapnel contains 227 8 oz. balls; the 8-inch contains 376 10 oz. balls; and the 9-inch, 564 12 oz. balls. The 16-pounder shell contains 63 large bullets and 56 small ones; the 12-pounder breech-loading shrapnel contains 42 bullets, 18 to the pound; and the 9-pounder, 21 of the same bullets. From time to time, as the patterns of the shell alter, these numbers are slightly varied. The above figures are, therefore, given only as exhibiting approximately the capacity of shells of this class. As *man-killing* projectiles, the effect of the rifled shrapnel shell is tremendous. It is intended to be opened at a certain distance in front of the object to be fired at, when the bursting charge, ripping up the sides of the shell, liberates the bullets, which proceed onward in a curved cone, the apex of which is at the point of explosion. On one occasion, at Dartmoor, the 12-pounder shrapnel, firing nine effective rounds, gave 652 hits of all sorts, of which 374 were "throughs." In the recent trials against the German gun at Shoeburyness, the shrapnel shell more than once greatly distinguished itself. For example, out of 5 rounds fired at 800 yards with percussion fuses, the effects were on one occasion no less than 103 hits per round, against 33 hits with the German common shell. At 1,500 or 2,000 yards the shrapnel gave from 30 to 40 hits per round. In the course of the 16-pounder trials, the following results have been obtained. At 1,000 yards, against two rows of targets, 67 hits per round; at 1,500 yards, 82 hits per round; at 2,000 yards, 70 hits per round. These are prodigious effects, particularly when it is considered that to produce them it is not necessary to make a good shot every time—that is to say, the shell may be burst from 50 to 150 yards short of the object with excellent effect, thus giving a large margin of permissible error in the laying of the gun, and in the preparing and burning of the fuse. And the great advantage of the shrapnel over the segment is, that it can be used with excellent effect with a "time" fuse, as well as with a "percussion" fuse—in other words, it is independent of the character of the ground over which it may be fired; whereas the segment, requiring an accuracy of action not to be obtained in the field with time fuses, can be effectively used only with percussion fuses, and is thus useless over boggy, or very broken, or very soft ground. To discuss the subject of shrapnel *versus* segment as it deserves, would occupy far more space than can here be allotted to it. What we have said as to the relative merits and performances of the two, will show that both shells possess considerable merit, the shrapnel having the advantage in general utility and effect.

With these remarks we conclude our hurried and imperfect sketch of rifled projectiles. But before closing this chapter, we should wish to make a few remarks upon the subject of fuses for shells. In the case of Palliser shells no fuse is required, the heat generated on impact being sufficient to fire the powder. But with other shells a fuse is necessary. There are two great classes of fuses, time and percussion (or concussion). The time-fuse is a contrivance for igniting the bursting charge of a shell (whether common, shrapnel, rifled, or smooth-bore) at any particular *time* after the shell leaves the muzzle of the gun. Various sorts of time fuses have been proposed, and of these varieties several have found a temporary footing in our service. The typical time-fuse, however, is the Boxer (Fig. 2), in which a cylindrical column of fuse composition (which burns at the rate of 1 inch in 5 seconds) is disposed vertically in a truncated wooden cone. By means of horizontal side holes, placed one-tenth of an inch apart measuring vertically, the wood can be easily pierced at any required point, opening a vent for the burning composition, which instantaneously flashes down the vertical powder-channel. For example, supposing that the shell is required to burst $2\frac{1}{2}$ seconds after it leaves the muzzle, the side hole marked $\frac{5}{10}$ ($= \frac{1}{2}$ inch $= 5$ half-seconds $= 2\frac{1}{2}$ seconds) would be bored through into the composition; the flame would come through when the composition had burnt down to that point, and would proceed by a flash down the powder-channel to the bursting charge of the shell. Breech-loading time-fuses are made on the same principle, with the addition of a detonating arrangement in the head for igniting them, this being necessary because the fuse cannot, as in the case of the muzzle-loader, be ignited by the flash of discharge.

Percussion fuses are of infinite variety, and great has been the expenditure, often fruitless, upon their production. They are intended to explode the shell on its striking an object, and without reference to its time of flight. One of these fuses, the Pettman, may be taken as a type (Fig. 3). In this fuse a small brass ball, coated with detonating composition, is enclosed between two supports, one of which rests upon a wire (and a lead cup), which is broken (and the cup is crushed) by the shock of discharge. The ball is thus liberated, and on impact is thrown violently against some part of the interior of the fuse and exploded. The flash passes at once to the bursting charge of the shell. By an ingenious arrangement in the head of the fuse, which our space does not permit us to describe, this fuse may be used for either rifled or smooth-bore projectiles, the conditions of which are different.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XIV.—SYSTEMATIC COLLECTIONS, ETC.

Details of Systematic Collection.—Practically, the "displayed" specimens in the public galleries and the "store specimens" in the adjoining studies would form one series. In 1862, Dr. J. E. Gray reported that he exhibited in zoological galleries 140,000 specimens, and that he had in store for the use of students (including under that term "experts" in zoology) 489,000 specimens, making a total of 629,000 specimens for the national illustration of zoology. This number included varieties and duplicates, but in the new museum "all specimens that are

*absolute duplicates** should be disposed of, as Thomas Bell very properly pointed out to the committee on the British Museum, and to that end should be kept in a separate department in the basement, for the purpose of exchange with dealers or private naturalists, or for replacing damaged specimens. Of late years, however, the question of the origin of species has made us regard duplicate specimens with an entirely different eye to what we did before, for many "varieties" which formerly would have been looked upon as mere duplicates have now become as important as "species." But a few years back the Museum was sadly deficient in specimens that were needed to prove or disprove Darwin's theories. On Professor Owen being applied to by a celebrated naturalist, in 1860, to assist him in procuring the specimens illustrative of the species and varieties of pigeons, he could not find more than twelve varieties of the most common domesticated pigeons, and three skeletons. The collection possessed specimens of the "tumbler," but not one of the common "pouter" pigeon, for at that time the series promised by Dr. Darwin to illustrate his work had not reached the Museum; and Professor Owen was forced to state, "As to showing you the varieties of species or any of the phenomena which would aid in getting at that mystery of mysteries, the origin of species, I am obliged with shame to say, I can show you none of them." But surely our country ought to possess specimens of everything that is known to naturalists, and expect in our national museum to find (at least in the future) all that is attainable.

Another point of the utmost importance connected with the systematic collection is that the skins, skeletons, spirit and histological preparations, models, eggs, nests, nidamental structures, and fossil species, at present widely scattered over the British Museum, should be amalgamated into one series. In regard to the amalgamation of the fossil with the recent species, very decided opinions have been expressed by Drs. Sclater, Wallace, and other eminent naturalists, including Professor Flower, who thus conveys the general feeling on this important question:—"If the construction of the new museum tends to perpetuate the present artificial distinction between extinct and recent species of animals, it will hinder instead of promote the progress of any general conception of the organic world as a whole, and will also impose unnecessary difficulties in working out the minute comparisons by which the affinities and gradations between the various units of which that world is composed are recognised."†

Professor Flower, in the same article, thus fully justifies the prevailing opinions I have advocated in these articles:—"We are only beginning to form any idea of the enormous numbers of specimens actually required to enable us to rest our generalisations relating to most zoological problems upon a firm basis, and of the importance of keeping these specimens in such a condition, and so placed, that they can be examined and compared with the greatest facility. Provision should, therefore, be made in the new museum for the great bulk of the collection being thus treated. It would be quite a mistake to suppose that they would then be shut up and put away, and that the public have no further concern in them, and ought not to be expected to pay for their accommodation. They would be in exactly the same circumstances as the books in a well-arranged library, and ought to be equally accessible under suitable regulations; and *there are thousands of people who will read with interest the conclusions that scientific men will draw from their study of them, who would never care to see, or if they did, never learn anything from, the specimens themselves.*"

Much greater care should be given to "setting up" the stuffed animals and mounted skeletons in an artistic manner than has hitherto been thought necessary in this country, though the educational importance is fully appreciated by the curators of the Stuttgart Museum, which Mr. Alexander Agassiz, after visiting all the great collections, regards as the most instructive museum in Europe. To this end the most artistic taxidermists should be secured—men who should be artists in the true sense of the word, and who could render the characteristic aspect and motion of the animals represented. Think of the common cat as a familiar illustration of the "characteristic motion" of animals: see how upright she stands on her paws, head erect, tail moving in graceful undulations, whiskers bristling, eyes looking straight forward; suddenly they flash with a brilliant phosphorescent emerald-green light, the fore part of the body is simultaneously depressed, the limbs from the paws to the elbows nearly touch the ground, the hind quarters are raised and the limbs thrown backwards, while the tail lashes from side to side with vicious fury; then how stealthily, with undulating back, she creeps forward, and with noiseless bound springs upon her prey, with talons till now sheathed, and with white, sharp, dagger-like teeth, crushes her victim in the dust, anon flings it in the air, plays with it, pats it tenderly with her cushioned but ruthless paws, till it suits her pleasure to give the *coup de grâce*. What taxidermist, unless deeply imbued with an artistic appreciation of his subject, could, with plastic touch, imbue the dead skin with any of the characteristic aspects here described; yet there are, or have been, such men who could blend artistic feeling with scientific truth, as Waterton of our own country, Verreaux of Paris, and the Stuttgart staff.*

The "deadly-lively" stuffed beasts that are yet too prevalent in our existing museums, do more harm than good among the class for whom they are chiefly intended—viz., the uninitiated in natural history. In our national museum, at least, they should be rendered as life-like as the taxidermist's skill will admit of; and we know what Waterton's fingers could effect, guided by a naturalist's appreciative feeling. Far more must also be done in rendering by wax modelling the soft parts of mollusks, tube-bearing worms, coral-forming animals, etc., in connection with their shells and hard parts; while many other groups, such as Hydrozoa, Actinea, Polyzoa, the Ascidians, Nudibranchiata, Vermes, Starfishes, etc., the flowers and fruit of plants, etc., could only be rendered with lifelike aspect by means of carefully-executed wax models. The embryological and anatomical character must often be represented by the same means; while the bones of unique specimens, whether of recent or fossil species, such as the Dodo, Mylodon, etc., might be rendered in counterpart by means of plaster models, that would be undistinguishable from the original specimens. Though, as a rule, wall-cases and floor-cases are best suited for the display of the vertebrate classes, and table-cases for the invertebrates, minerals, etc., no fixed rule should be laid down, but that sort of case should be selected which is best suited for the particular group to be arranged for public inspection. It may here be noted that Schlegel, the director of the extensive Netherlands National Zoological Museum, at Leyden, arranges each "family" in a separate case; and by the position and arrangement of the several links of the chain of Nature in natural sequence, imparts knowledge by that method of silent information which may be made of such educational value in any museum. The "life history groups" should include illustrations of the habits and mimetic† characters of animals.

The botanical collections allow of but limited display, as they mainly consist of specimens of plants and parts of plants, mounted on separate sheets of paper, which are laid upon each other like the leaves of an unbound book, and kept in the trays of small cabinets, which allow of their being arranged or rearranged in blocks, that form series which illustrate the systematic geographical or historical aspects of botany. Such portions are known as herbaria, and being from their nature unfitted for public display, are consequently kept in the studies for the use of working botanists. It is only the hard parts, such as the seeds, fruit, leaves, wood, or sections of woods, fossil species, models of plants, etc., that are suited for public inspection, which is the reason the botanical department makes so little display at the existing museum, though the herbaria is one of the finest and most extensive in the world. Still much more might be effected than has yet been attempted by the use

* It may here be noted that in rendering fossil forms, many specimens may, from their damaged condition, be required, to show by a group all the characters of one species. Such duplicates could not, for instance, be regarded as "absolute duplicates."

† *Nature*, May 26th, 1870.

* The members of this staff have published a work that should be better known to the curators of this country, viz., "Die Praxis der Naturgeschichte, Dermoplastik und Museologie, oder der Modelliren der Thiere und das Aufstellen und Erhalten von Naturaliensammlungen." Edited by Herr Martin, and published by Voigt, of Weimar.

† See Fig. 7, page 329, Vol. III., of THE TECHNICAL EDUCATOR for an example of this phenomenon.

of such *multum in parvo* screens as are shown in Fig. 26 (page 64), and by models of botanical type forms, when the natural object would lose its characteristic aspect and colours, if exposed to light, etc.

The public galleries should be devoted to the illustration of structural botany to the fullest extent practicable; the studies to the specific character of plants. Both Sir Charles Lyell and Professor John Phillips attest to the value of recent specimens for the studies of the palæophytologist, and that, without the aid of the national botanical collections, they could not have identified certain fossil species described in their geological works. The late Robert Brown made it a proviso in his will that his collection of fossil woods should only be given over to the trustees of the British Museum on the condition that it should "form part of the botanical *exhibition*, under charge of the Keeper of Botany;" and should they decline to accept it on this condition, it was to be handed over to the Edinburgh Museum! The mineralogical collection, besides the series of meteorites at present displayed, should include such a series of rock specimens as is described in Cotta's "Gesteinslehre," and a complete suite of crystal models, for both of which there is existing material at the British Museum, though not displayed for want of space. The geological collection should be arranged in stratagraphical order, with restorations of extinct forms such as Unger* and Waterhouse Hawkins have suggested, the latter as to individual forms, the former as to entire landscapes; including both plants and animals, and such accessories as would best convey to the popular mind the creative phases of our earth, while not forgetting the practical requirements of the working geologist.

The wall-space above the cases in the galleries should be utilised with diagrams, the subdivisions of classifications, and maps showing the geographical range of the species displayed on the shelves beneath; while in the stratagraphical gallery, geological should be combined with geographical mapping of the distribution of animal or vegetable life.

TECHNICAL DRAWING.—LXXXI.

DRAWING FOR CABINET-MAKERS.

OBJECT DRAWING.

The student is at this stage advised to work through the course of lessons on Object Drawing, commencing at page 3, Vol. II., of The Technical Educator. The examples there given will show him the application of the Perspective lessons, and he will thus be prepared to benefit by the following studies.

Fig. 622 is a sketch of a drawing-room chair, placed so that its sides are at different angles to the plane of the picture. In commencing this subject, sketch the general ground-plan on the principle shown in the drawing of the kitchen chair, observing that in this case the plan is not a square, the chair being wider in front than at the back.

The uprights of the back are, as in the perspective study alluded to, continuations of the back legs. The light is supposed to come from a point in front of the object and in the left side, and above it; thus, the left angle of the seat and the left-hand front leg receive the strongest light. The side which is in full shade is not visible in the present view; the seat, which is slightly rounded, receives in consequence a slight shade towards its distant edge. The student is advised to draw several chairs placed in different positions in relation to his eye and to the light.

Fig. 623.—This sketch represents a "Davenport," or small writing-desk, supported on a pedestal containing drawers, and by two spiral legs in the front.

In commencing this subject, draw the entire cubical block out of which the whole mass could be carved, regardless of legs or recess—drawing, in fact, the mere packing-case in which the object could be contained. When this has been done, draw the line giving the bottom of the desk on each of the two visible sides; and as of course these lines are in the object horizontal, forming as they do two of the edges of the bottom of the desk, and as they are parallel to the bottom line of the side, and to that which would connect the two legs in the front, they would converge to the same vanishing points as the two last mentioned.

Next sketch the front edge of the desk, which will also converge to the left-hand vanishing point, to which the line joining the two legs has been drawn, the rule being borne in mind that all lines which in the object are parallel to each other vanish in the same point. The two short perpendiculars for the ends of the front of the desk having been drawn, raise the distant perpendicular for the back of the desk, and draw a line to the left-hand vanishing point, this line, too, being of course parallel to the front edge. Now complete the desk by drawing the slanting edges, etc.

Draw the perpendicular indicating the width of the pedestal containing the drawers, and also the corresponding one in the distance, connecting these at the bottom by a line parallel to the front of the desk, and thus converging to the same point. The framing at the bottom is now to be drawn, the lines converging to the left-hand vanishing point.

The spiral legs must now occupy attention. For each of these a central perpendicular should be drawn, and a line on each side of it, between which the whole pillar is to be contained, observing that the distant one must be rendered slightly narrower than that in the immediate foreground. The oblique and curved lines giving the twisted appearance will be easily followed from the example.

The light is supposed to come from a point in front of the object, above it in height, and on the left side; the front therefore receives the light, the brightest being at the angle, and on the slanting surface of the desk. The whole of the distant side is covered with a shade, whilst a shadow is cast by the desk on to the front of the pedestal. The right side of the pillars too are shaded, a reflected light being seen at the edge. The cast-shadow on the pedestal, as well as that on the ground, must, it will be remembered, be darker than the shades.

Fig. 624.—This sketch represents a loo-table. The spectator is in this case supposed to be *sitting* nearly in front of the object. The method of drawing circles in perspective has been explained elsewhere, and it will therefore be understood that if the spectator were supposed to be *standing*, the point of sight would be higher, and the width of the ellipse representing the circle would consequently be greater, and that as the point of sight were lowered the breadth would decrease, until it became lost altogether; thus a circular disc, when placed immediately on a level with the eye, is seen only as a straight line.

In commencing this figure, draw a perpendicular line for the centre of the pillar, and a horizontal crossing it for the long diameter of the ellipse representing the top of the table, which should now be sketched, as well as the double line representing the edge and the framing around it. The pillar should next be drawn, and then the base. This is an equilateral triangle in perspective, its angles being cut off, and its sides curved inward. Care must be taken in drawing the distant side of this triangle, which should in the first instance be sketched as one continuous curve, although afterwards interrupted by the pillar which crosses it. The thickness of the base, and the feet on which it rests, should now be drawn.

The light comes from a point in front, but slightly towards the left of the object. It will be seen that as the curved surface presents no sharp edge to the light, there is no definite point at which the shade commences. The brightest light is at the part of the circular edge and frame nearest the light, and from this it gradually tones down into the darkest shade, slightly lightened at the distant portion by reflected light.

The cylindrical pillar is shaded in a similar manner, but over a great portion of this the shadow of the top of the table is cast, and falling from above on a cylindrical surface, its outline is a curve tending obliquely downwards. It must be impressed on the student, however, that unless a shade is bounded by the absolute lines of a surface on which it falls, it must have no definite outline—its edge must be slightly softened off. Observation will show the student that the extremes of a shadow are always more or less toned down into the tint of the surface on which it falls.

The right-hand side of the triangular base is next to be shaded, and then the shades on the feet. The cast-shadow on the ground, and that cast by the projecting edge of the top on the framing beneath it, will complete the drawing.

* "Unger's Ideal Views of the Primitive World, in its Geological and Palæontological Phases." Photographic illustrations. 4to. Edited by Samuel Highley, F.G.S., etc.

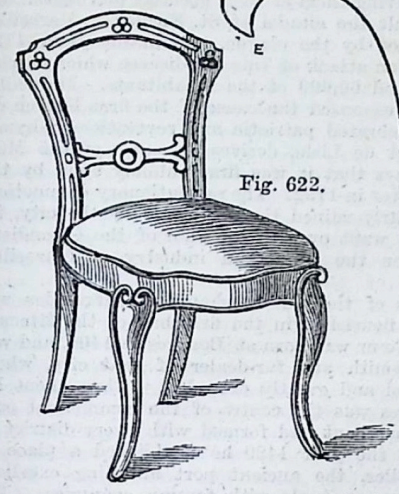


Fig. 622.

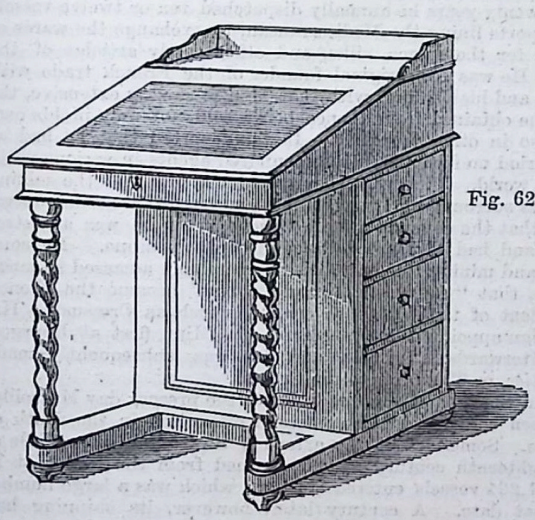


Fig. 623.

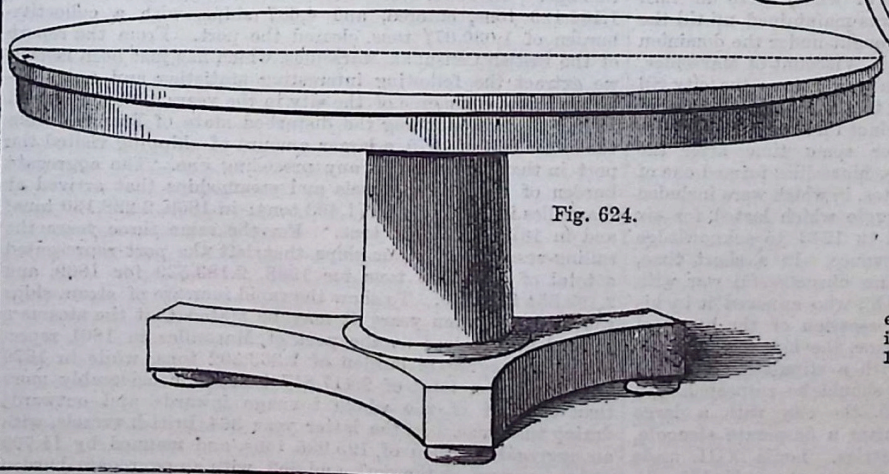


Fig. 624.

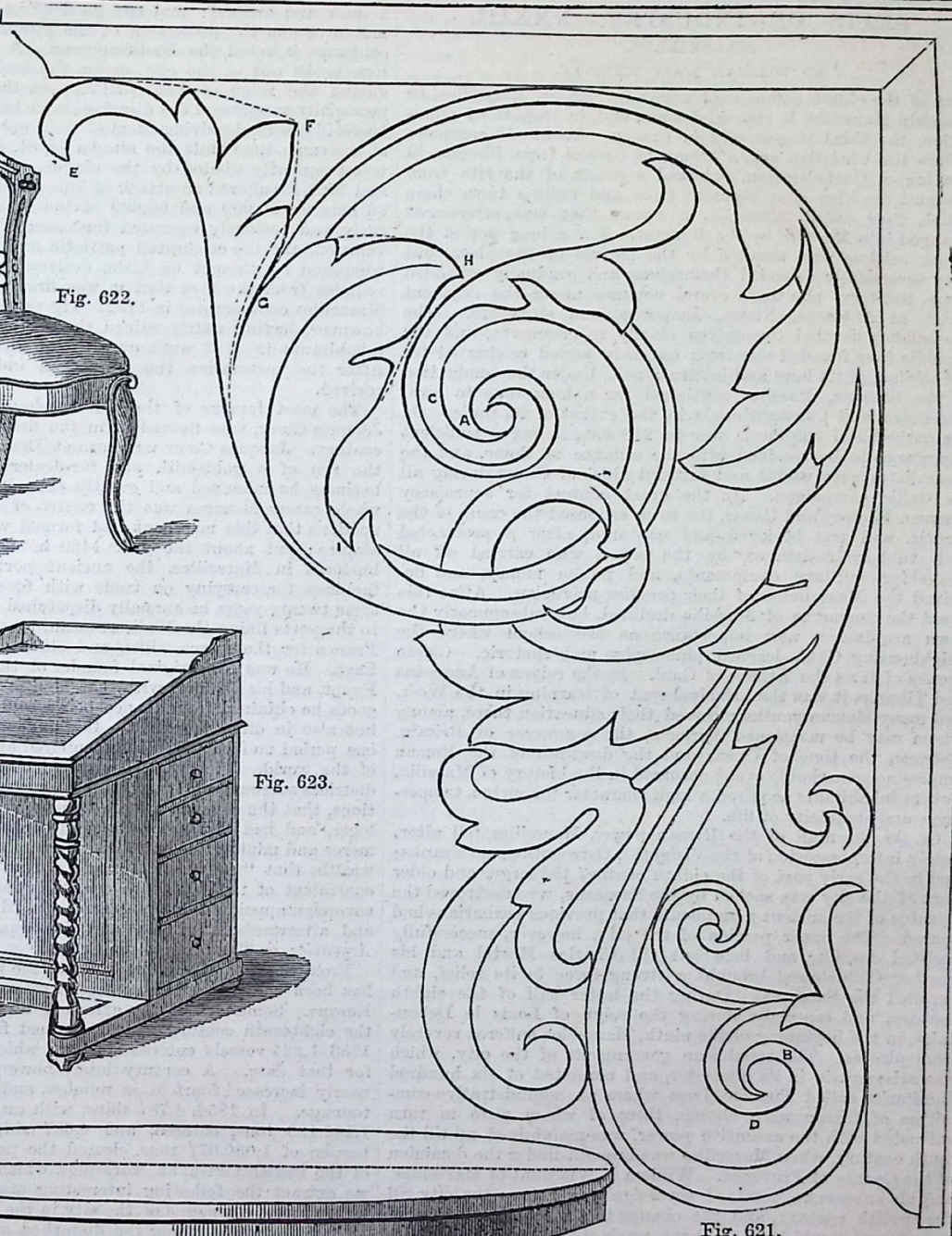


Fig. 621.

[NOTE.—A description of the mode, etc., of drawing Fig. 621 will be found in "Technical Drawing," LXXX., page 101.]

SEATS OF INDUSTRY.—XXXIII.

MARSEILLES.

BY WILLIAM WATT WEBSTER.

One of the oldest commercial towns in Europe, Marseilles, or properly Marseille, is the chief mart, and, in respect of population, the third largest city in France. About six centuries before the Christian era, a colony of Greeks from Phocæa, in the Ionian Confederation, obtained a grant of the site from Naunus, the king of a Ligurian tribe, and built a town there which they called *Massalia*, a name that was afterwards changed into *Massilia* by the Romans. For a long period the Greek settlers were assailed by the natives of the place, but they successfully defended themselves, and gradually extended their territory, planting several colonies along the adjacent coast, at Antipolis, Nicæa, Emporiæ, and elsewhere. The Massaliotes devoted themselves chiefly to commerce, and the republic they founded was from an early period celebrated for the wisdom of its laws and institutions. Under the domination of the Romans, Massilia continued for a long time to rival Alexandria and Constantinople in the extent of its trade. On the outbreak of the Punic war in 218 B.C., it was of sufficient importance to be received into the alliance of Rome, and the Massaliotes were useful and faithful allies of Cæsar during all his Gallic campaigns. In the great contest for supremacy between Pompey and Cæsar, the town espoused the cause of the former, and was besieged and captured, after a protracted and stubborn resistance, by the latter, who carried off all the ships, military equipments, and public money, and deprived the Massaliotes of their peculiar privileges. After this event the commerce of Massilia declined, but subsequently the town acquired a new importance as the school where the neighbouring Gauls learned philosophy and rhetoric. Cicero speaks of it as the Athens of Gaul. In the reigns of Augustus and Tiberius it was the principal seat of learning in the West, and many Roman youths received their education there, among whom may be mentioned Agricola, the conqueror of Britain. Between the time of Cæsar and the downfall of the Roman empire no remarkable event occurred in the history of Massilia, but its inhabitants acquired a high character for virtue, temperance, and simplicity of life.

On the downfall of the Roman power, Marseilles fell alternately into possession of the Visigoths, Ostrogoths, and Franks; and in the early part of the eighth century the larger and older part of the city was sacked by the Saracens, who destroyed the remains of the ancient monuments that previous barbarians had spared. The upper portion of the city, however, successfully resisted assault, and held out till Charles Martel and his brother Childebrand brought a strong force to its relief, and expelled the Saracens. During the latter half of the eighth century, and especially during the reign of Louis le Debonnaire, in the beginning of the ninth, Marseilles suffered severely from pirates. The republican government of the city, which was aristocratic in its character, and consisted of six hundred dignitaries called Timachi, from whom an administrative committee of fifteen were chosen, three of whom were in turn entrusted with the executive power, was maintained up till the tenth century, when Marseilles was brought under the dominion of the Counts of Provence. William I., Viscount of Marseilles, and his successors, retained sovereign power over the city till the twelfth century, and the change to a monarchical form of government would seem to have produced no bad effects on its industry, commerce, and arts. For some time after the restoration of republican institutions, Marseilles formed one of a confederation of similar smaller states, in which were included Arles and Grasse; but after a struggle which lasted for six years, the city was again compelled in 1243 to acknowledge the authority of the Counts of Provence. In a short time, however, Marseilles was involved in an unsuccessful war with Charles of Anjou, brother of Louis IX., who annexed it to his territory, and it remained in the possession of the house of Anjou till 1482, when Charles de Maine, the heir to the line of Anjou, bequeathed it to Louis XI., with a stipulation that the time-honoured liberties of the city should be respected. In 1524, Charles de Bourbon besieged the city with a large imperialist force, but the citizens, after a desperate struggle, succeeded in repelling their adversaries. Louis XIII. made Marseilles a station for the French navy, and provided it with a dock and arsenal; and one good effect that followed these measures was the dispersion of the pirates that had for many centuries infested the Mediterranean. A formidable insurrection broke out in the city, under the leadership of Noiselles, during the reign of Louis XIV., but the Grande Monarque personally suppressed the disaffection in 1660, and punished the Marseillaise by depriving them of their peculiar privileges. He at the same time built the citadel of St. Nicolas. Marseilles was frequently visited by the plague, and in the years 1720 and 1721 it suffered an attack of this fell disease which carried off between 50,000 and 60,000 of the inhabitants. Marseilles early and zealously espoused the cause of the first French revolution, and the celebrated patriotic and revolutionary hymn, composed by Rouget de Lisle, derives its name of the Marseillaise from the fact that it was first publicly sung by the Marseilles confederates in 1792. The revolutionary commotion, however, having nearly ruined the commerce of the city, its inhabitants in 1793 went over to the side of the Girondists. After the restoration the trade and industry of Marseilles revived.

The most famous of the old merchants of Marseilles was Jacques Cœur, who flourished in the first half of the fifteenth century. Jacques Cœur was born at Bourges in 1400, and was the son of a goldsmith and fur-dealer of that city, whose business he inherited and greatly extended. Throughout his whole career Bourges was the centre of the commercial connections that this merchant had formed with every district in France; but about the year 1429 he established a place of business in Marseilles, the ancient port affording excellent facilities for carrying on trade with foreign countries. For some twenty years he annually dispatched ten or twelve vessels to the ports lining the Mediterranean, to exchange the wares of France for the spices, silks, and other costly articles of the East. He was the original founder of the French trade with Egypt, and his dealings with that land were very extensive, the goods he obtained from thence being sold not only in his own but also in other countries. It was reported that he had at one period no fewer than three hundred agents in various parts of the world. Charles VII. gave him a grant of the mining districts surrounding Lyons, and so successful were his operations, that the common people believed that he was an astrologer, and had discovered the philosopher's stone. By commerce and mining this enterprising merchant amassed so much wealth, that "As rich as Jacques Cœur" became the French equivalent of the Latin proverb, "As rich as Crœsus." His sovereign appointed him Master of the Mint, first at Bourges, and afterwards at Paris, and he was subsequently made *Argentier*, or Treasurer to the Crown.

From the time of Jacques Cœur to the present day Marseilles has been the principal commercial emporium in the south of Europe. Some idea of the extent of its trade in the middle of the eighteenth century may be formed from the fact that in 1753 1,264 vessels entered its port, which was a large number for that date. A century later, however, its shipping had nearly increased fourfold in number, and considerably more in tonnage. In 1858, 4,787 ships, with an aggregate burden of 1,102,123 tons, entered, and 4,687 ships, with a collective burden of 1,030,077 tons, cleared the port. From the report of the British Consul at Marseilles, which has just been issued, we extract the following interesting statistics and notes relating to the commerce of the city in the years 1868, 1869, and 1870. Notwithstanding the disturbed state of France during the latter half of 1870, a larger amount of shipping visited the port in that year than in any preceding one. The aggregate burden of the sailing-vessels and steam-ships that arrived at Marseilles in 1868 was 2,171,463 tons; in 1869, 2,228,130 tons; and in 1870, 2,237,732 tons. For the same three years the sailing-vessels and steam-ships that left the port represented a total of 2,181,582 tons for 1868, 2,183,539 for 1869, and 2,190,854 for 1870. To show the rapid increase of steam-ships within the last ten years, it may be stated that the steamers entered and cleared at the port of Marseilles in 1861 represented an aggregate burden of 1,362,392 tons, while in 1870 they reached a total of 2,417,817 tons, or considerably more than one-half of the whole tonnage inwards and outwards during that year. In the latter year 364 British vessels, with an aggregate burden of 195,935 tons, and manned by 11,709 sailors, arrived at the port, and 352, with an aggregate burden

of 188,717 tons, and an aggregate crew of 11,480, left the port. In the foregoing numbers were included 148 British steamships, with a total burden of 122,519 tons, and a total crew of 9,263 men. Of these vessels 51 are the property of the Peninsular and Oriental Company, who at the end of the year quitted the Marseilles station, and adopted that of Brindisi for the Indian mail service. A very large passenger traffic has been carried on at this port for the past few years, the arrivals and departures fluctuating from 150,000 to 180,000 yearly. Marseilles now possesses 572 sailing vessels, collectively of 87,201 tons burden, and 119 steamers, of 94,872 tons. The custom-house revenue of the port for 1870 amounted to 18,009,370 fr., against 15,225,727 fr. for the preceding year. In 1864, which was an exceptionally brisk year, the total exports of Marseilles reached a value of 1,102,243,663 fr. The merchandise exported in the year 1867 was estimated to be worth 627,021,967 fr., and the precious metals 129,005,663 fr., giving a total value of 756,027,630 fr. Among the principal articles of export in that year were included woollen fabrics to the value of 37,000,000 fr.; silk goods, 32,000,000 fr.; cotton goods, 28,000,000 fr.; refined sugars, 35,000,000 fr.; and wines and spirits, 25,000,000 fr. A striking fluctuation in the importation of wheat into Marseilles for the past few years is noticeable in the returns. In 1870, 5,256,030 hectolitres (three hectolitres being equivalent to 1 quarter 0·254 bushels) came into the port; while in 1868 the quantity was 10,486,800, out of 15,918,500 hectolitres, which was the total importation of wheat into France in the same year. Of other grains, such as rye, barley, oats, and maize, 2,573,300 hectolitres were brought into the port in 1870. About 1,492,800 hectolitres of wheat and wheat flour were exported from Marseilles in the same year, 392,400 being sent direct to England. The raw sugar imported from abroad in 1869 amounted to 68,645 tons, and in 1870 to 76,390 tons; and in the former of these years 7,505 tons, and in the latter 1,911 tons of home-grown beet-root sugar were received in the city. In 1870, 44,214 tons of refined sugar were exported from Marseilles, of which 12,760 were sent to Turkey, 9,422 to Italy, 6,840 to Algeria, 2,358 to Egypt, and 2,888 to Greece; while about 4,000 tons of raw sugar were re-exported. Oil-seeds have recently acquired an important position in the commerce of Marseilles, the imports of this article for 1870 having amounted to 184,000 tons. These oil-seeds consisted of sesamum seed from the Levant, India, and the coast of Africa; linseed and cotton-seed from the Black Sea and Egypt; and cocoa and palm nuts from the coast of Africa. The oil-mills of the city turned out about 115,000 tons of oil-cake in 1870, 29,000 tons of which were shipped for England, out of a total exportation of 31,700 tons. There was a marked decline in the quantity of cotton imported into Marseilles in 1870 as compared with the three preceding years. In 1869, 150,572 bales came to the port, and in 1870, 98,884, about 19,000 only being brought from India. The annual value of the silk imported represents upwards of 100,000,000 fr., and the quantity landed at Marseilles in 1870 amounted to 32,039 bales, but a large portion of this and of the stock of silk at Lyons was re-shipped for England on the outbreak of the war. China, Japan, Bengal, Persia, Asia Minor, and the coast of Syria supply most of the silk brought to Marseilles. The wool trade of the city has fluctuated nearly to the same extent as the cotton trade, only 91,518 bales of wool having been imported in 1870 (the whole being brought from Mediterranean ports, with the exception of 4,654 bales from Buenos Ayres), against 139,910 bales in 1868. In 1870, there were imported into Marseilles 10,356 bales of sheep and lamb skins, nearly the whole of which came from the River Plate; 31,355 bales of goat-skins, mostly from Morocco; and 716,797 hides, of which 200,000 came from the River Plate, 60,000 from Brazil, and the remainder from other countries. The olive oil imported in the same year amounted to about 40,000 tons of ordinary quality for manufacturing purposes, and 5,000 tons of refined oil; and the oil-mills of the city produced 70,000 tons of oil from the various sorts of oil-seeds, 12,000 tons of which were exported. Owing to the direct importation of petroleum from the United States into the various Mediterranean ports which formerly drew their supplies from Marseilles, the trade in this article has recently declined, but 42,743 barrels of crude, and 32,797 of refined petroleum were landed in 1870. The exportation of wine from this port has considerably increased within recent years, 35,580 pipes having been shipped in 1869, and 26,963 in 1870; but the trade in spirits has fallen off, only 2,500 pipes having been shipped in 1869 and 1870 respectively, against 5,775 in 1866. About 15,000 tons of argentiferous lead were brought to the city in 1870, and a large portion of it was desilverised there. The blast-furnaces of Marseilles turned out about 30,000 tons of iron in 1870, from ore imported from Algeria, Spain, and Italy. Out of 627,000 tons of coal brought to Marseilles in the same year, 81,000 tons came from Great Britain; about 200,000 tons were consumed in the city, and the remainder was either used by the steam-shipping, or sent to the different countries of the Mediterranean. Some 70,000 tons of soap are annually manufactured in the city. The flour-mills of the district number about 100, and comprise 600 pairs of stones. Large quantities of flour are annually produced, and the exportation of this article is important, having amounted to 65,000 tons in 1870. About £600,000 worth of work was executed in the engineering establishments of Marseilles in 1867, which then employed 4,000 men, but there has since been a considerable falling off. Large quantities of cattle are annually imported into Marseilles from Algiers and Sardinia. From the former country 19,109 bullocks and 318,621 sheep were landed in 1868; and from the latter 16,173 bullocks and 715 sheep. In 1870 the figures were:—From Algiers 1,880 bullocks and 218,694 sheep; and from Sardinia 4,932 bullocks and 69 sheep. About a fourth of the sheep and a third of the bullocks are consumed in Marseilles, and the rest are driven into the neighbouring departments. The trade between Marseilles and Algeria is very extensive, as may be judged from the fact that 766 vessels, with an aggregate burden of 290,259 tons, left the port in 1867 for that colony, while 573 ships, of collectively 274,812 tons burden, arrived from it. Ship-building has almost entirely left the city, and little more than repairs are now done there. The sea-fishing, which a few years back occupied a considerable number of ships, now only occupies about a dozen, and between 300 and 400 men.

The harbour of Marseilles is one of the finest and largest in the world, being capable of accommodating 2,000 vessels. It comprises (1) the Old Port, which is 1,000 yards long, and 300 yards wide; and the Port of La Joliette, constructed in 1853, which is about 600 yards long and 460 yards wide, and is surrounded by spacious quays furnished with iron tramways; (2) the basins of Lazaret, Aren, and Napoleon, opened within recent years; (3) a very old and insufficient graving dock; and (4) two refitting docks constructed in the same canal that unites the Old Port with the Port of La Joliette. The latter port is formed by a breakwater 1,224 yards long, thrown out into the sea, running parallel with the shore, and at a distance of 1,312 feet from it. Marseilles is still deficient in quay-space, and ships have frequently to discharge their cargoes lying to three deep. The great dock warehouses, built of stone and iron, can contain some 40,000 tons of merchandise. Le Vieux Port is formed by an inlet of the sea which runs eastward into the heart of the city, and the roads are defended by the fortified islands of If (crowned with a castle, once a state prison), Pomeque, and Ratonneau.

In Marseilles, the western quarter, which is crowded with narrow, irregular streets, is the older, the poorer, and the seat of the principal industries. Connecting the old and the new towns is a beautiful street or promenade called Le Cours, planted with a double row of trees, adorned with fine fountains, and bordered with many elegant mansions. Here the shops and houses rival in splendour the finest of those in Paris. The new parts of the city are admirably laid out. A new town that sprang up with remarkable rapidity on the site of a hill removed in course of making the port of La Joliette, and on the land recovered from the sea, is known as the maritime city, and is capable of containing 60,000 inhabitants.

The city is healthy. There are few remarkable buildings or antiquities in Marseilles. The New Cathedral, which is supposed to be built on the site of a temple of Diana, is a basilica in the Byzantine style, shaped like a Greek cross, and surmounted by very picturesque domes. Marseilles is the capital of the department of Bouches du Rhone, and possesses a court of first jurisdiction, a court and chamber of commerce, an exchange, a royal naval observatory, a mint, an academy of sciences, belles-lettres, and art; schools of medicine, music,

drawing, and hydrography; a public library containing 60,000 volumes; botanical gardens, a picture gallery, and various learned societies. The population in 1861 numbered 219,984, or including the whole commune and the military, 260,910; and at present it is upwards of 300,000. There are about 900 *bastides* or villas in the vicinity of Marseilles.

CAPITAL AND LABOUR.—VI.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

COMBINATIONS OF LABOUR.

THE possessors of property may unite together in order to make their property more useful to themselves, and so turn, in the language of economists, their wealth into capital. They may entrust the management of this capital to the hands of others, and they may, if they prefer it, manage their capital themselves. In the former case they will get interest, in the latter they will get profit as well as interest, or, as I have already explained the facts, they will get wages for the labour which they give in superintending their own property, together with a greater or less addition, according to the character of the business in which they are engaged, which will cover the risk of loss.

Now the labourer, when his economical position has been analysed, will be found, as has been generally stated before, to stand in exactly the same place that the capitalist does. His education and maintenance are, to all intents and purposes, an investment of capital for productive purposes. The duration of his powers is a matter of risk. He is engaged in an industry which will assuredly sooner or later wear him out, and therefore he does in his wages receive something which, over and above the risk which he incurs, will compensate for the inevitable exhaustion of the powers which make him an industrial agent. But as the remuneration of his labour, in the shape of wages, and of his employer in the form of profit, are really identical forms of economical distribution, there is a question which is constantly raised as to the relations between the employer and the labourer, and which is characteristic of them. I refer to the question as to whether the master gets too much and the workman too little, in the distribution of that which remains over and above in the market price of the article, after all necessary charges are liquidated.

A combination of labourers has for its object the appropriation to the labourer of a greater share in the surplus from which both wages and profit are derived. This object is not always assured, but it certainly subsists in all such combinations. It was historically the cause of these associations, for up to within fifty years ago the law inflicted serious penalties on all those who entered into combinations for the purpose of raising wages, and the law had adopted this policy for nearly five centuries. It was by no means surprising, when this law was repealed, that workmen entered into these mutual arrangements; for it is very natural that persons should think, as soon as they are permitted to do what they have been forbidden before, that there is some advantage to be gained by availing themselves of the permission.

But, apart from these historical circumstances, there are considerations, partly of principle and partly of fact, which justify the associations of working men for the purpose of bettering their condition, and obtaining an increase in their wages. It may be the case, as some persons of great judgment and experience have averred, that these arrangements can be proved to be superfluous, for that the rise in the wages of some kinds of labour may be explained by causes which are quite independent of trade combinations, that the power possessed by those who live by their labour of entering into such associations greatly varies, and that if the policy of these arrangements is expedient it ought to be available for all who might see good to take advantage of it. It may be proved too, perhaps, that the establishment of the system may in certain kinds of industry do great injury to the public at large, and in particular to that portion of the public which is least provided with the necessaries or conveniences of life. But even if these reasonings can be maintained, they will not militate against the justice of a combination of labourers, though they may disprove its expediency.

A labourer has something to sell. This is his labour. It is just as saleable an article as a pound of sugar or a yard of cloth, and its advantageous sale is as much a matter of interest to the labourer as the sale of sugar and cloth is to the grocer and the draper. Now, if it be admitted that capitalists can unite their capitals together in order to get advantage by mutual association, there can be in the nature of things no reason why labourers should not have and use the same liberty. A trade union is virtually a labour partnership. It may not be, and perhaps is not, the best form of labour partnership—we shall have occasion to recognise, hereafter, much more advantageous forms of association—but it is based on precisely the same principle as that which induces men to put their property together in order to found a bank, to construct a railway, or advance a loan to a government.

Part of the machinery by which a trade combination tries to enforce its regulations is a strike—that is, a refusal to work unless certain demands are conceded. Now such a course of action is very inconvenient, and occasionally very alarming. It may be very disadvantageous to the public, and still more disadvantageous to the persons who adopt the expedient. It may entail great loss, and may fail of its end. It may attain its end, and the public may suffer, because they may have to pay more for a service than the service has hitherto been worth. It may be superfluous, because the rise in wages which it is intended to achieve may come from natural causes. It may be even unfair, because it is possible that such a rise ought to come from natural causes only. But, judged by the ordinary practice of those who are engaged in business, it exactly corresponds with the line of action adopted by traders in goods. No one finds fault with a merchant because he speculates on a rise in the price of the articles in which he deals, and withholds his goods from the market in order that he may get a better price hereafter than the market offers him at present. Such speculations are justified on grounds of private right, and sometimes even on those of the public good. But a working man who, in concert with others, declines to work for wages which he thinks insufficient, is only doing that which is an admitted right in the conduct of business by a private merchant. No one would probably dispute his right to choose his own terms if he acted as an individual, and there is no reason in the nature of things why he should not act with others in seeking to obtain for all what he thinks will be for the good of all. On grounds of principle, then, combinations of working men have a clear economical defence.

They have a further justification in fact. There can be no doubt that in matters of bargain an individual workman is, as compared with an employer, in a weak position. The man who employs many hands has greater advantage in constraining a workman to accept terms, than an individual workman has of exacting them. There is not much doubt, whether they do so or not, that employers have naturally greater opportunities for uniting together, in order to adopt a common policy, than their workpeople have. Even if the men can be brought to act together, the power of endurance, however disastrous may be a trade difference, is greater on the part of employers than it is on the part of the men. The very fact that the employer is possessed of wealth which is generally saleable, while the workman is possessed of one kind of wealth only, which under the present circumstances he declines to sell, is positive proof of the superiority of position enjoyed by the employers.

In giving these economical excuses for those combinations and their action, I must not be supposed to think that such expedients are desirable, or under certain circumstances necessary. I only say that they are, under existing circumstances, defensible. They arise from causes which are in themselves exceptional. I may illustrate what I mean by a fact of my own experience. Before the outbreak of the American civil war, there were very few trade-unions in the United States. Just after the commencement of that war, a tariff was passed by the American Congress, of a highly protective character, in the interest of employers or manufacturers. I took occasion, in conversation with an American of eminence, to predict that speedily, under that tariff, the States would swarm with trades-unions. Events proved that I was right. But my prediction was based on the principle which I have often insisted on, that where there are employers and working hands there is always a question afoot, whether the profits of the employer do not take over-much from the wages of the workman.

ENGLISH CARRIAGE-BUILDING.—I.

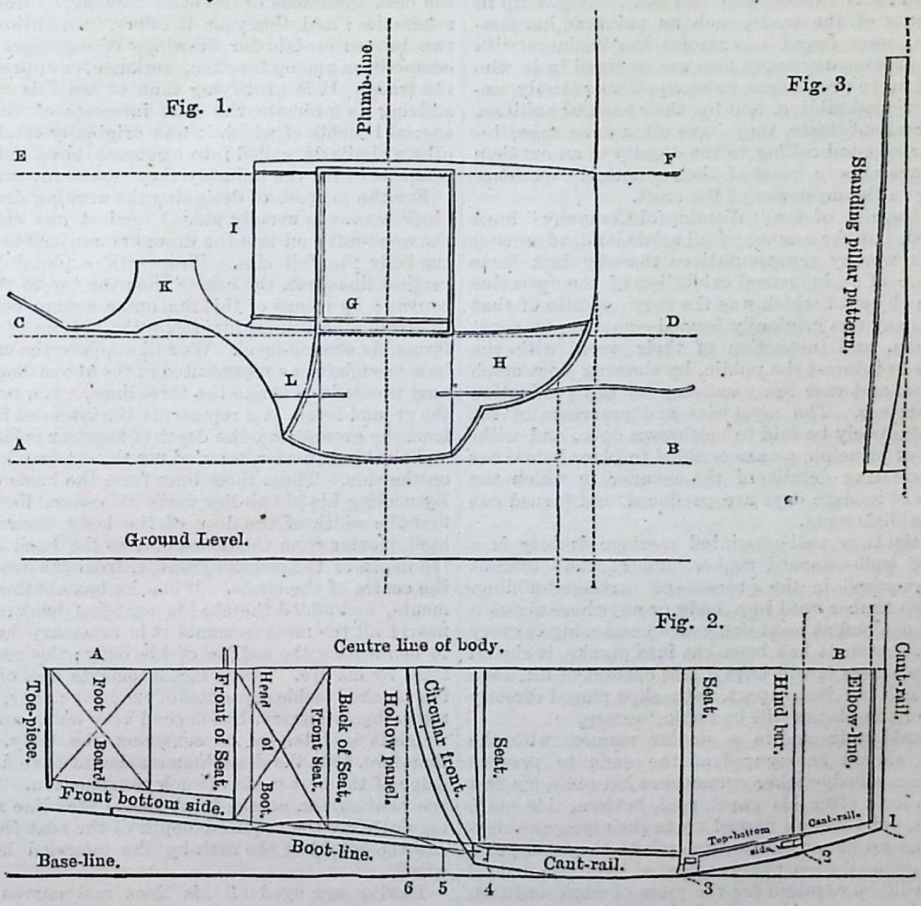
BY A LONDON COACH-BUILDER.

INTRODUCTION—HISTORY OF CARRIAGE-BUILDING—ESSENTIALS—LUMBER AND PANEL STUFF—WORKING DRAUGHT—CANT-BOARD—STANDING PILLAR.

It is a moot point whether carriage-building is to be regarded as one of the fine arts, or whether it is to be classed among the branches of industry which are included in the list of mechanical trades. The question is well worth the consideration of all those who adopt carriage-building as their vocation in life, because on the conclusion at which they arrive depends, to a great extent, their chances of success; for the higher the opinion men entertain of their occupation, the more are they likely to pursue it as a labour of love. On the one hand, it is said that, although essentially and of necessity for its practical purposes a mechanical occupation, it nevertheless includes so much of what is termed *art* in the higher sense of the word, that it may justly claim to be considered more than a mere industrial manufacture. On the other hand, it is contended that this branch of industry is of so multiform and composite a character, that it cannot in any sense lay claim to individuality which is the characteristic distinction of an art.

It is quite true that the occupation of the coach-builder differs widely in this respect from that of the sculptor, the painter, or the architect, or even from the pursuits of the goldsmith or the potter, inasmuch as each of these has to deal only with one substance, or one class of substances, and is dependent alone on his own efforts and skill; while the former has to deal with a great variety of materials of very opposite natures, and to command a whole train of auxiliaries, every one of whom must be well skilled in his department, or the work when completed will be marred, notwithstanding the superior abilities of the superintending head; but it is equally certain that if this same superintending head possess not in a high degree the distinguishing characteristics of the sculptor, the artist, and the architect, he will inevitably fail to make a proper use of the mechanical skill that is placed under his control, or to obtain a high position in his art.

In the earlier ages of carriage-building, and even to a comparatively recent period, little was necessary to those engaged in it, beyond some rude knowledge of the laws of mechanics. No doubt the war-chariots of the ancient Greeks, described in the classic language of Homer, were very primitive constructions; the state carriage of our own Elizabeth, judging from the descriptions we have of it, must have been a very lumbering contrivance; and even the state-carriage in which "Mr. Speaker," only the other day, proceeded to St. Paul's Cathedral to take part in the thanksgiving service offered on the occasion of the recovery of the Prince of Wales from his severe illness, is little more than a venerable piece of gilt gingerbread. But the wonderful development of this elegant and useful branch of industry during the present century, especially during the last five-and-twenty years, has rendered far higher qualities essential for its successful prosecution, and under whatever heading it may be classified in the world's industries, the more eminent of our builders quietly pursue it as an art. That it is so considered in many European states is shown by the fact that in France, Belgium, and Germany, the respective governments have established technical schools, where youths intending to follow it are instructed in drawing, modelling, in the harmonious arrangement of colours, in chemistry, in metallurgy or the proper working of metals, and in the principles and applications of mechanics and mathematics to manufactures. It is to be regretted that more pains are not taken in this respect with our English apprentices, who mostly pursue their study of the different branches in which they are destined to labour with very little knowledge of the qualities or properties of the materials that are placed in their hands. But, notwithstanding our remissness, many of the heads of our large establishments have, by their own technical knowledge, and their taste and experience, overcome the difficulties that the want of a better system might be expected to give rise to, and if we pay a visit to their factories or show-rooms, we shall see at once to what perfection carriage-building has been brought in this country. We shall, moreover, be convinced not only that it is an art, but one calling forth no ordinary skill, for the carriage-builder has to combine in one harmonious whole a great variety of essentials, over each of which he must possess a mastery before he can succeed.



The art of carriage-building is of very high antiquity, and was still of ancient date in the days of Homer, who flourished about 900 years before the Christian era. The war-chariots of the Pharaohs are mentioned by Moses in the sacred writings, and it may be flattering to the pride of our English manufacturers to know that the scythe-armed chariots of the ancient Britons were copied and adapted by the Romans for purposes of luxury and convenience. But however much the Greeks or Romans may have elaborated their system of carriage-building, they made very little improvement upon the vehicles used by the ancient Egyptians, and after the fall of the Roman empire the art slumbered altogether for many centuries.

On its revival in the fifteenth century, it became rapidly a lucrative branch of industry, and attained great excellence, first

in Italy, and afterwards in Spain, France, and England. In 1668 Charles II. granted a charter incorporating the Worshipful Company of Coach and Coach-harness Makers in the City of London, conferring on them certain privileges and rights in order to encourage and protect a trade that had not been very long established in this country, and which was thought to require support. At that period trades were mysteries and their processes secret, and protection and support was required by that company in order to preserve those mysteries and processes inviolate.

For a long period none who embarked in this business was regarded in the trade as a legitimate carriage-builder, but he who had been brought up to the art of framing bodies or carriages. But in process of time it was shown that taste was the chief requisite, and as taste is not a necessary result of peculiar instruction, it followed that it must be had wherever it could be obtained; and others who had been brought up in different departments of the trade, such as painters, harness-makers, or smiths, were found to exercise the business with success. At the present day many men are engaged in it who have been brought up to professions or occupations entirely unconnected with carriage-building, and by their natural abilities, combined with excellent taste, they have often done more towards raising their adopted calling to the dignity of an art than some others who are able to boast of their practical experience and early training in the mysteries of the craft.

The protective theories of the "Worshipful Company" have long since exploded, but the company still exists, and, advancing with the times, its worthy representatives recently lent their hall for the purpose of an industrial exhibition of the operative coach-makers, the object of which was the very opposite of that for which the company was originally formed—namely, to court inquiry, comparison, and inspection of their work, with the enlightened desire to interest the public, by showing how much ingenuity, patience, and care are necessary for the production of a first-rate carriage. The mysteries and processes of the trade may therefore fairly be said to be thrown open, and without any violation of principle we are enabled to place before our readers some interesting details of the manner in which the elegant equipages of modern days are produced and turned out from our best establishments.

The first essential in a well-appointed carriage factory is a plentiful stock of well-seasoned timber, and of the different woods that are required in the process of carriage-building. There should be no timber used in a body or anywhere about a carriage that has not had at least one year in seasoning to every inch in thickness. After it has been cut into planks, it should be kept in a place where it will have a free current of air, each plank separated half an inch apart, with slips placed directly over each other, or the planks will be liable to warp.

Panel stuff should be treated in a similar manner, with the addition that it should be secured at the ends to prevent splitting; and when a body-maker commences his work, his first care should be to look after his panel, roof, bottom, side stuff, and lining boards, get them all planed up to their proper thickness, and put them up in some safe place where they will get a moderate degree of heat, each panel separated by slips; and all other stuff that will be required for the piece of work in hand, should be selected and put aside. If all these things be strictly attended to, there need be no trouble about bad joints; and it will be to the employer's interest to look after such workmen as do not know enough to see to these things themselves, and have these rules strictly enforced; but an intelligent workman will soon appreciate the advantage of getting his stuff ready at the commencement, instead of waiting till he wants to use it.

The timbers and woods commonly in use in our carriage factories are English ash plank, which is used for the framework of bodies and the timbers of carriages, Honduras mahogany for panelling, white pine for roofing, seat-boards, and the under parts of bodies, and birch for boot sides; but of late years Canadian black walnut wood has been advantageously introduced, and is often used in the place of birch, or being cut into panels is found, for many purposes, an excellent substitute for Honduras mahogany; the sapling oak or hickory is used for the spokes of wheels, and other woods are used for minor purposes. Many schemes have been tried for forcing the desiccation of timber, but we have no faith in any of them. The well-ventilated timber-shed, which gives alike protection against damp and the direct rays of the sun, offers the surest and safest means of seasoning or drying timber. Subjected here to atmospheric influence, the process may be slow; but while the moisture evaporates, the fibrous texture of the wood gradually consolidates, and none of its virtue is lost; while by any forced process the too rapid evaporation of moisture leaves the grain open and porous, and the virtue of the timber is more or less destroyed.

But before these timbers can be brought into use, it is necessary first to design the carriage that is to be built, and here we find at the outset that the eye and hand of the artist are wanted, for on the manner in which the carriage is first placed on the canvas entirely depends its appearance when finished: the importance, therefore, of a good draughtsman is at once apparent. In view of this vital necessity in the art of modern carriage-building, the Worshipful Company of Coach-makers annually offers prizes of silver and bronze medals for the best specimens of freehand drawing, as well as for practical mechanics; and this year it offers, in addition, two silver and two bronze medals for drawings of carriages *to any scale*, for competition among foremen, workmen, or apprentices engaged in the trade. It is gratifying thus to see this ancient City guild striving to promote the best interests of the trade, for the special benefits of which it was originally established, while all others similarly called into existence have outlived everything connected with the industry they represent, except the name.

For the purpose of designing the working draught, a large size black canvas is usually placed against one side of the wall of the wood-loft; on this the draughtsman sets to work to delineate the body the full size. First with a plumb-line he strikes a vertical line down the centre from the top to the bottom of the canvas; by means of this line and a square board he is enabled to strike a horizontal line along the bottom of the canvas which forms his ground-level. We will suppose the carriage wanted to be a brougham, as represented in the above diagram (Fig. 1). He next proceeds to strike the three lines, A B, C D, E F, parallel with the ground-level. A B represents the intended height of the body from the ground; C D the depth of the door below the door-rail, G, and the hind quarter, H; and E F the extreme height of the body on the side. These three lines form the basis of his operations. By making his plumb-line mark his central line, he measures off, first the width of the door of the body, then the depth of the hind quarter from the door-pillar to the back of the body, then the depth of the circular front, I, from the front of the door to the centre of the circle. When he has obtained these measurements, and added thereto his seat-line back and front, he has nearly all the measurements it is necessary he should work to in delineating the outline of his body; the rest is mostly regulated by his eye. These measurements are, of course, made by the required inside capacities of the body; they, therefore, are not altogether arbitrary, but depend very much upon the manner in which it is intended to construct the body. It is requisite, therefore, that the draughtsman should have an intimate knowledge of the best mode of such construction. The width across the boot-side K, at the front inside seat-line L, will have to be regulated by the required depth of the seat from back to front, and the height of the arch by the intended height of the front wheel.

Having arranged all his lines and curves in pleasing and graceful form, and finished his drawing to his satisfaction, he next proceeds to prepare his cant-board, which, to the workman, is far more important even than the drawing itself. The drawing presents the side view of the body on the flat; but as it is not intended to build it flat-sided, but with a nicely rounded surface, it is essential that this rounding shall be planned out before the work is commenced.

The rounding which is given from end to end of the body is technically called the *side cant*, and the rounding from the top to the bottom the *turn under*. We have heard of carriage-builders, and of men eminent in their vocation at the present day, allowing this rounding process to be performed in their factories in a very primitive way. The timbers which are to form the frame-work or skeleton of the body are cut square and framed together, and then chiselled off to the required roundness, as a stonemason would chisel off blocks of granite, or as Robinson Crusoe gave form to his boat out of the solid tree. We can hardly credit this, for the waste both in time and material must be enormous, nor do we believe that modern requirements can be adequately fulfilled by such a process. The

proper plan is to arrange everything beforehand, and this is done on the cant-board which shows the side cant, and with the standing pillar pattern which shows the turn under. The manner of proceeding is as follows:—

Take a clean pine board, plane it up to a smooth surface, and run the outer edge with a trying plane, so as to render it perfectly straight. This straight edge of the board must now be taken to represent the flat surface of the side of the body, and along it must be marked off the dimensions of the body, beginning at the top corner pillar marked 1, and following the figures 2, 3, 4, 5, and 6. From 1 to 6 will thus give the extreme outside measurement of the body, and the respective measurements from point to point.

To illustrate the system, we must now draw attention to the diagram showing the cant-board, which is drawn to scale of half an inch to the foot. The first mark on the board shows the position of the corner pillar, the second the hind bottom-side, the third the hind standing pillar, the fourth the back of the front pillar, the fifth the toe of the front pillar, and the sixth the outside of the circular front of the body. The circular line between these points shows the contraction from the widest part of the body, and the manner of distributing it from end to end; and the line A B, which runs parallel with the base-line of the cant-board, shows the centre of body from side to side. The lines which follow the point which shows the outside of the circular front mark the boot-line, the arch beneath, the hollow panel at top, and all the distances from point to point till we come to the toe-piece, or extreme end of the body and boot as a whole. All these delineations give us the exact plan, together with the dimensions of the body in every particular, except the turn-under.

We only now require the standing pillar pattern to give us the contraction at the bottom; we can then proceed to give the dimensions in full detail from side to side of the body, the width across the widest point being first determined by arbitrary decision.

The standing pillar, as probably our non-professional readers will have already surmised, is that on which the door is hinged. We have described it on the cant-board, to scale which shows the turn-under to 2½ inches, so that the outside width of the body at the bottom will be five inches less than at the elbow. It may be as well here to state that there is no rule about the side-cant or the turn-under; they depend entirely upon the will or taste of the workman.

SEATS OF INDUSTRY.—XXXIV.

LE HAVRE.

BY WILLIAM WATT WEBSTER.

"PARIS, Rouen, and Le Havre form but a single city, of which the river Seine is the principal thoroughfare." So said Napoleon Bonaparte, President of the French Republic, to a deputation from Le Havre who, having learned that he was on his way to their town, met him at Rouen, and assured him of an enthusiastic welcome. This was in the year 1802. The professed object of Napoleon's visit was to contrive means by which the commercial facilities of "the Port of Paris," as he designated Le Havre, might be improved, and he prophesied that a great future was before it. It was destined, he declared, to rival the most renowned ports of Europe, and to direct, for the profit of France, a portion of the trade by which the Hanseatic towns and the Dutch ports had successively enriched themselves. But Napoleon did nothing to fulfil these predictions. Eight years later he returned to Le Havre, and although in 1805 the town had profited by the large share it took in providing boats for the fleet that the ex-first consul, and by that time Emperor of the French, fitted out at Boulogne for the conquest of England, he found its commerce and industry had considerably declined in the interval. During nearly the whole of that period, the port had been closely blockaded by an English squadron. English men-of-war were then in possession of the roads, and their presence, and the desolation of the town, reviving the memory of recent defeats in Spain, at St. Jean d'Acre, Trafalgar, etc., drove the Emperor into a towering passion. There was no talk now of the commercial interests of Le Havre, and it was only after the downfall of Napoleon that the town recovered its trade and prosperity.

At the date of Napoleon's last visit, Le Havre was about 300 years old, having been originally founded in 1509 by Louis XII., who intended it as a harbour of refuge for the French navy; but little progress was made in its erection during that monarch's reign. The word Havre signifies "port," and is supposed to be a corruption of the Celtic *aver*. Francis I. took the town under his protection, and conferred on it the name of *Franciscopolis*, but under Louis XIV. it was designated *Le Havre de Notre Dame de Grâce*, and, with the exception of a short period during the Reign of Terror, when it was re-christened *Le Havre-Marat*, it has been known by that title and its abbreviations, *Le Havre de Grâce* and *Le Havre*, ever since. Before the time of Louis XII., Le Havre was a small fishing village on the border of a marsh, and the port was a creek formed by the tides. It was from this place that Henry of Richmond embarked in 1485, with 4,000 men furnished by Charles VIII. of France, for Milford Haven and Bosworth Field. In 1516 the decree for the erection of a fortified town and harbour at Le Havre was issued, and in the following year the first stone houses were built. The first large vessels entered the port in 1520; but five years later the works were wholly destroyed by a high tide. Francis I. entertained the idea of building a fleet, and setting out from Havre for the conquest of England, as William of Normandy had started from Honfleur on his successful expedition five centuries before. But the project ended in a series of ridiculous catastrophes. An enormous vessel of upwards of 2,000 tons was constructed, and heavily plated; but it was found that she could not be launched, and her timbers were eventually used in the erection of houses for the burghers. Still Le Havre continued to grow, and Francis made it the rendezvous of his navy. At this king's death, in 1547, the town possessed formidable defences against its two enemies, the sea and the English, and was on a fair way to prosperity.

Le Havre has suffered severely from war almost from the time of its foundation down to the year 1871. In 1562 the Prince of Condé, the leader of the Huguenots, delivered the town over to the keeping of Queen Elizabeth, who entrusted the command of it to Ambrose Dudley, Earl of Warwick; but within a year the English were expelled, after an obstinate siege, directed in person by Charles IX. and his mother, Catherine de Medici. A citadel having been built, and Le Havre being regarded as a place of strength, it was frequently assailed. It has been four times bombarded by the British, in 1694, in 1759, in 1794, and in 1795. On the first of these occasions, preparations were being made at the port for another invasion of England. During the minority of Louis le Grand, the commerce of Le Havre, being skilfully fostered by Richelieu, made a rapid advance; and about this time the Queen of Charles I., accompanied by her daughter, the Princess Henrietta of England, took up her abode within the walls of this town. The names of Vauban and Colbert are associated with the improvements made in the port in the reign of Louis XIV., and with the development of the trade of the town.

In 1716, the second year of the reign of Louis XV., the North Jetty, which had long been in progress and frequently interrupted, was completed, and in the same year a curious phenomenon is reported to have taken place at the port. The tide rose to a greater height than had been previously known, and remained at that elevation for twenty-four hours, doing a great amount of damage. The French East India Company and the companies of Senegal and Guinea made Le Havre their entrepôt, and the chief seat of their commercial operations. With the exception of visits from the Kings of France, and the sieges by the English, which have been already referred to, no other events of great interest or importance took place at Le Havre till the time of Napoleon, and the incidents since that date are not of a remarkable character.

In the beginning of 1871 the town was threatened with an attack by the Germans, and the inhabitants were consequently filled with anxiety; the docks were empty, the warehouses nearly bare of goods; industry was at a standstill, and the hospitals were filled with wounded soldiers. But the armistice came in time to save the town from the horrors of a siege, and on the conclusion of peace its merchants set promptly and actively to work to replenish their exhausted stores. However, although during three months of the year commerce and industry were in a state of stagnation, the operations carried

on throughout the remaining nine months were so extensive that 1871 was, on the whole, a prosperous year for the city. In 1871, 1,379 British vessels, aggregating 510,602 tons burden, and with crews numbering in all 23,776 men, entered the port, against 1,371 British vessels, aggregating 520,019 tons burden, and with crews numbering in all 26,397 men, in 1870. During both of these years the number and burden of the British shipping that visited the port were greater than in the three preceding years. The total entries of shipping of all nations at the port of Le Havre in 1871 amounted to 6,274 vessels, representing an aggregate burden of 1,340,915 tons, and an aggregate crew of 70,842 men, 2,572 of these vessels being engaged in the foreign, and 3,702 in the coasting trade. In 1869 the total entries of shipping numbered 5,713, with an aggregate burden of 1,323,286 tons, and an aggregate crew of 71,162 men.

Besides an immense outer harbour, with 1,600 mètres of quay, there are eight tidal basins, including one opened last year, and two lock basins, at Le Havre. The Old Basin, excavated in the time of Richelieu, has been repaired and rendered accessible to the largest vessels. The Commercial Basin can accommodate with ease 200 ships, and the Basin de la Barre is still larger than the Commercial Basin, with which it communicates. The new dock is a fine piece of work, and preparations are being made for widening the entrance to the port, and removing an angle where many large steamers have run aground. There is a peculiarity of the harbour of Le Havre that deserves to be mentioned. It has the great advantage of retaining the tide at nearly full height for three or four hours, whereas elsewhere the tide begins to recede from the time it ceases to rise. This phenomenon, which has never been satisfactorily explained, permits ships to enter and leave the port by the same tide. The coasting vessels arriving at Le Havre transfer their cargoes to steamers, and partly to large barges termed *chalands*, which are towed by steam-tugs as far as Rouen, and thence by horses to Paris. Lines of sailing packets are established between this port and New York, New Orleans, etc., and there is regular steam communication between it and London, Southampton, Liverpool, Dublin, Glasgow, Hamburg, Rotterdam, St. Petersburg, Constantinople, Odessa, Havannah, St. Domingo, Vera Cruz, and the principal maritime towns of South America, India, and China.

Most of the foreign and colonial produce destined for the consumption of Paris is imported into Le Havre; and although its imports are only about half the weight of those of Marseilles, there is little difference in the total value of the imports of the two towns. The principal imports consist of cotton, coal, sugar, coffee, indigo, timber, iron, tin, dried fish, hides, and tobacco; and the principal exports are silks, woollen and cotton goods, lace, gloves, shoes, trinkets, perfumery, champagne and other wines, brandy, glass, furniture, and books. Le Havre is to the north of France what Marseilles is to the south, and it ranks next to that city in the extent of its shipping trade, the commerce of Le Havre being estimated at between a fourth and a fifth of the whole of France. In 1867, 22,752 emigrants sailed from Le Havre, and in 1864 there belonged to the port 368 merchant ships, with a total burden of 114,645 tons. There are three extensive ship-building yards in the town, and numerous establishments for the manufacture of all the articles required for the outfit of vessels. The rope-works are highly celebrated, and the sugar refineries, one of which furnishes employment to 250 workmen, are very large. One firm of sugar refiners at Le Havre are reported to have distributed among their workmen, out of their profits last year, no less a sum than £10,000.

In the spinning factories of the town 14,500 spindles are kept at work, and 550 workmen find employment in 370 weaving shops, while 580 are occupied at the tobacco factory. The engineering establishments and copper foundries of Le Havre are very extensive, and it also possesses large corn and rice mills, and glass and chemical works. It is estimated that the total annual value of the manufactures of Le Havre exceeds £2,500,000. The total value of its exports and imports amounts yearly to about £52,000,000.

In 1861 the population of Le Havre numbered 82,009, exclusive of from 5,000 to 6,000 men and boys, forming the crews of the vessels constantly in the port. Lately the walls of the town were demolished to allow of its expansion. Le Havre contains few public buildings of note either for their elegance or for their age and associations. With the exception of a few wretched wooden houses, the town is substantially built, and the streets are laid out with great regularity in straight lines, which intersect each other at right angles. A few magnificent streets and boulevards have recently been constructed, and great progress has been made in the embellishment of the town. Le Havre is the birth-place of Bernardin St. Pierre, the author of "Paul and Virginia," and Casimir Delavigne, the author of the celebrated play, "Louis XI."

WOOL: ITS INDUSTRIAL APPLICATIONS.

BY PROFESSOR T. C. ARCHER.

II.—THE ANCIENT USES OF WOOL AND OTHER ANIMAL FIBRES.

BEFORE wool can be applied to any economic purpose it must be removed from the skin of the animal, and this in our time is done by shearing with sharp steel shears; but wool was used long before such implements were invented, and was probably obtained first by collecting the stray locks, which were detached by thorns, and other causes, from the animal whilst alive. Doubtless, also, it was pulled from the skins of animals slaughtered for food. In most climates the sheep parts with the outer layer or oldest portion of its mature wool in the spring of the year by a natural process of moulting, and this would afford the rudest barbarian a very easy means of collecting it, but not perfectly or in good order, and a knowledge of this imperfection in time would lead to the invention of shears, and a great improvement in the wool crop, for not only would the first yield be larger and better, but the equally shorn and short covering left would grow more regularly, and ensure an improved clip for the next season. The most ancient practice of pulling the wool at the proper season from the skin of the living animals, notwithstanding its great cruelty, has continued in some localities even up to the present century, chiefly in Iceland, Shetland, and Orkney, but it is now almost, if not quite, abandoned.

When shears were actually invented is not known, but it is certain that this implement existed at least 1800 years B.C., because we read in the Book of Genesis that "Laban went to shear his sheep," and from that time to the present they have been generally used by the most civilised nations, whilst those less so have pursued the old and barbarous custom of pulling the wool. In each case it would have to be combed and spun into thread, by processes which will be described in a subsequent chapter, our present object being rather to make the reader acquainted with the ancient applications of the material.

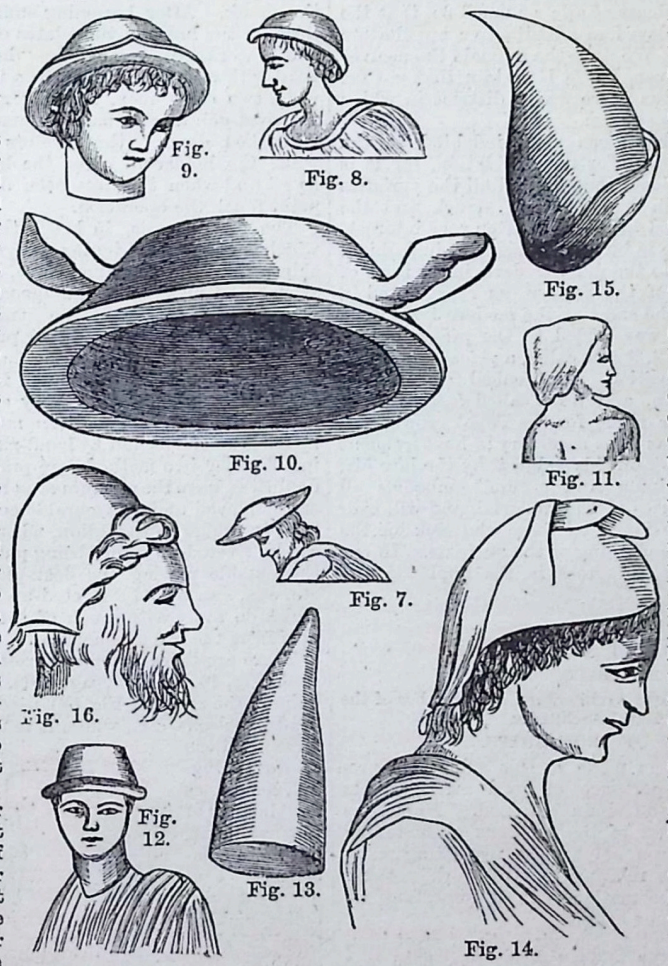
It is impossible to give any opinion upon the time when the wool of animals was first used for garments. The Bible contains more information upon the subject than any other book, though much is found scattered through the writings of classic authors; but recent discoveries of the remains of pre-historic life seem to point to an antiquity for the manufacture of clothing from wool far greater than we have been accustomed to assign to it, and this is rendered all the stronger when we consider that ancient authors, both Biblical and classical, all speak of the art as one in which great perfection had been attained. Thus we read in Exodus xxxv. 35, Moses says, "And of the weaver, even of those that devise cunning work;" and many similar passages could be quoted.

But notwithstanding the very abundant evidence that the weaving of cloths of wool dates back to the commencement of historic times, some authors advance strong arguments in favour of the supposition that the art of producing woven cloth for apparel was not the first application of wool. There are many reasons for this assumption, foremost amongst which is the probability that the felting property of wool would be noticed by the wearers of sheep-skins, which we naturally suppose was the first method of utilising the material for the purposes of human clothing. From long-continued use portions of the wool on the skin garments would become felted, and this being observed would suggest the employment of loose wool, by working it up into felt for garments, but the earlier application of felt was in all probability confined to the manufacture of small

articles, probably entirely to the manufacture of hats. It would be very interesting if we could establish the truth of this suggestion, because it would show that this application of wool was coeval with man's civilisation, and has continued in use up to the present time. As a covering for the head, certainly felt is the earliest material known, and both the statuary and other artistic representations of the ancient Greeks and Romans afford abundant evidence of such hats being generally worn. Thus in most of the representations of the ancient inhabitants of Troy and Phrygia, and the inhabitants of Asia Minor, as well as some mythical personages, such as Ganymede, a felt cap of the fashion known under the name of the Phrygian bonnet (Fig. 14), or "Cap of Liberty" of the moderns, is the head-dress, whilst a felt hat of another, but equally common shape, is usually placed on the head of Mercury (Fig. 10): these, with various modifications shown in Figs. 7 to 16, seem to have been almost universally used in Europe and Asia for a very great period of time, and they are still represented by the Moorish fez and the English "Jim Crow," etc.

But the discovery of the art of making felt could not long be confined to hat-making, and in time it was employed instead of skins to make a cleaner and more wholesome dress for the whole body. The Greeks were well acquainted with the manufacture and use of felt as early as the ninth century B.C., for it is mentioned in the Homeric poems ("Iliad," x. 265), and by Hesiod ("Op. et Dies," 542, 546); but it is most probable that they received the art from Asia, where both in Northern India and Persia it has been practised from a very high antiquity. The Persians used it as a covering for their horses, and most likely also for carpets. The Romans in the time of Julius Cæsar wore felt shirts as a protection from the arrows of Pompey's archers, and it is pretty certain they had learned this fashion from the Greeks, who also wore a *chlamys* of felt occasionally.

Felt shoes and linings for helmets were also amongst the ancient applications of this material, and the former use has endured to the present time, especially amongst the Russian peasantry, and poor classes in the towns, who use hats, coats, boots, and shoes made entirely of felt, and each article in one piece. We have evidence that the ancients manufactured felt on a large scale, to screen the defenders of fortifications from the missiles of the enemy.



We now proceed to examine the history of woven woollen cloths, and other applications of the material in ancient times.

No record exists of the actual invention, or even the probable time of the invention of weaving, and the earliest mention of woven woollen cloths indicates an advanced state of the art. Moreover, it must be borne in mind that the evidence of all ancient history is against the assumption that the vast flocks which constituted the wealth of the peoples described in the sacred writings and by classical authors, were not as a rule reared for food, but for either their skins or their fleeces. Thus we read in Proverbs xxvii. 26, 27, "The lambs are for thy clothing, and the goats are the price of thy field; and thou shalt have goats' milk enough for thy food, for the food of thy household, and for the maintenance of thy maidens." In this quotation it is clearly indicated that the chief use of the sheep was to furnish either skins or fleeces for clothing, and that of goats to yield milk of which cheese was made. But there is no reason to doubt that from the earliest times goats' hair was used for various textile purposes, and the milk of sheep was also used for food. Columella says the Nomades and the Getæ were called Galactopotæ because they were drinkers of ewes' milk. It would be very satisfactory if we could discover in any of the tombs of the ancients such satisfactory specimens of their manufacture of wool into clothing, as we find in the Egyptian tombs of linen cloths; but the liability of all animal substances to the attack of moths and other insect enemies, has probably prevented that, although specimens of fine cloths made of alpaca wool are said to have been found in some of the most ancient of the Peruvian places of sepulture.

Possibly the use of goats' hair for weaving is coeval with that of the wool of sheep; its greater length and silky fineness are more suggestive of such application; at all events, we learn from Exodus that it was spun and used in the form of cords and curtains for the tabernacle, and there are many allusions to the use of goats' hair cloths in the classic authors. Much coarse cloth at the present time is made in the East, chiefly in Syria, of goats' hair, and is used for tent-cloths, or for bags and sacks for agricultural produce, and the wrapping in bales of manufactured goods. This cloth is called in Syriac and the allied languages *shac* or *sac*, whence we obtain our word *sack*. And in view of this origin of the term we must always understand the term "sackcloth," so often alluded to in the Scriptures, to mean cloth of goats' hair. Besides cloths made of goats' hair, the material was much used by the ancients for cordage, especially for the rigging of ships. Aristotle, Callisthenes, Varro, Virgil, and Pliny all refer to this use of goats' hair, and tell us that the goats were then shorn the same as sheep.

Of the fabrics made from wool or hair, either of the sheep or goat, by the ancients, we find only meagre mention. Nevertheless, there is enough to show that such fabrics were manufactured, and became articles of luxury from the fineness and beauty of their manufacture, as well as of utility. Thus we find Strabo and other ancient authors speak with great respect of the Coraxi, who seem to have been the progenitors of the modern Circassians, as a nation who greatly excelled in the art of rearing flocks and utilising their fleeces. Moreover, Hipponax, who wrote 500 B.C., has left evidence that in his time that nation was celebrated for its manufacture of shawls, as he speaks of a woman wearing a Coraxic shawl. The same writer also speaks of the carpets of Miletus as being very famous. As, however, Miletus was the great port of Ionia, and at least a portion of Circassia was at that time occupied by an Ionian colony, we can easily understand the probability that Miletus was the mart for, and not the place of manufacture of, the beautiful carpets for which it was famous. The shawls possibly resembled, if they were not identical with, the Cashmere shawls of the present day, and the carpets were possibly felt cloths,

in which the patterns were felted in by a process which was shown in the Indian Department of the International Exhibition of 1871, and which possibly originated in the shawl manufacture. The examples alluded to were very curious; they were thick felt carpets, or *musnuds*, for sitting upon, and the patterns were in various colours on a drab ground; they were formed, not by any kind of printing process, such as would be employed in Europe for decorating felt fabrics, but by laying coloured wools, probably the refuse of the shawl manufacture, so as to form the patterns, and then beating them into felt. In this manner very effective and beautiful carpets were produced.

But besides the shawls and carpets of the Coraxi, the Ionians imported in all probability the wool itself, and rivalled them in the manufactures they produced from it, for Miletus is very frequently spoken of as the emporium for the finest of woollen manufactures, and those which were understood to be made at Miletus were regarded as the finest of all; so much so, that the term Milesian came to be employed as a distinctive appellation for wool of the finest quality. Whether the animals themselves were also imported is not known, but it is certain that not far inland from the port of Miletus there was a district in which wool of remarkable fineness was grown.

This part of our subject has been more indebted to the numismaticians than to any other for its elucidation, for it is chiefly on the coins of the ancients that we find all the varieties of costume of the periods when the coins were struck, and the information we are thus enabled to gather is often very interesting. Thus we learn that there is but little variation in fashion, from the most ancient Greeks to the most modern, in the form of the head covering, the *pileus* of the former, as represented in Figs. 11 and 16, being nearly the same as the modern fez, minus the silk tassel. When a brim was added to the *pileus* of the ancients, as in Figs. 8, 9, 10, 12, it was called a *petasus*, and was an indication of a superior position. The conical forms shown in Figs. 13 and 15 are Persian, and were called *tiara* by the Greeks, whence we derive our name for the Papal crown. In writing the present paper it has been necessary to have frequent recourse to the exhaustive work on this subject by the late Mr. James Yates, whose "Textrinum Antiquorum" embodies all that is known of the ancient uses of the material, and will ever be a work of the highest importance to those who seek for the soundest information as to the clothing of the ancients. In our next paper we shall show the progress in the application of wool since the commencement of Christianity.

SHIP-BUILDING.—XXI.

BY W. H. WHITE,

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THE RIVETING OF IRON SHIPS.

REPEATED references have been made to this subject in preceding articles, and the importance of good arrangements of riveting has been again and again enforced. Numerous examples have also been given of the methods of fastening together different parts of iron ships; but respecting many important facts and principles relating to rivet-work, nothing has yet been said; and as the matter is most important, we shall consider it in detail to some extent.

A great mass of facts respecting the strength of rivet-iron, of manufactured rivets, and of riveted work, has been got together as the result of experiments made primarily with a view to the improvement of bridge construction; and the knowledge so gained has also been of benefit to iron ship-building. Very few experiments were made in direct connection with ship-building until the new material came into general use in the Royal Navy; but since then numerous and valuable experiments have been made, from which have resulted considerable improvements. There still remains, however, much to be made the subject of trial in connection with the riveting of wrought-iron or steel structures, as any one will see who carefully goes through the excellent summary of our present knowledge on the subject, published by Mr. Reed in his "Ship-building in Iron and Steel."* For our present purpose it will suffice, however, to state clearly well-ascertained facts, and to draw a few practical deductions therefrom.

In Fig. 41 (Vol. III., page 351) an illustration is given of the form of rivet commonly used in iron ships, with what is termed a "pan-head." Sometimes the head is hemispherical in shape, and is termed a "snap-head;" but this is not extensively used. The process of making these rivets is a very simple one. First the bar-iron is heated in furnaces; then it is cut into the lengths required; and lastly, the head and the conical neck of each rivet are formed by being pressed into suitable dies. These operations were formerly performed by hand, but now they are done by machines—some of which are most ingeniously arranged—at much less cost and at a very rapid rate.

When required for use, the manufactured rivets are heated in portable hearths made for the purpose, means being commonly taken to keep the head and neck at a lower temperature than the shank. After becoming sufficiently hot, the rivet is driven through the holes in the plates or bars it is to fasten together, and a workman, termed the "holder-up," presses against the head with a heavy hammer, or a mass of iron termed a "dolly," while two other men, termed "riveters," beat down or clench the rivet-points with hand-hammers. When the point has been "knocked down," the riveters hold their hammers upon it while the holder-up gives the head a few blows, or "lays it up;" and when this has been done, a few more blows on the point finish the operation.

The foregoing is, in brief, the operation of *hand-riveting* which is adopted for by far the greater part of the work in iron ships. Riveting machines have, however, been in use for many years, and may be advantageously employed in fastening together such portions of the structure as can be completed, or nearly completed, before being put in place—viz., deck-beams, frames, etc. Portable riveting machines have also been devised, but have not yet found much favour, and do not seem likely to displace hand-riveting very soon. Experiments have been made to test the comparative merits of the work produced by riveting-machines and by hand-riveting, with the result of showing that the two methods are practically equal. The machines, doubtless, have the advantage as respects cost of work, when they are employed under favourable conditions, and are very largely used in bridge construction, where large pieces of the structure can be riveted-up before being put in place; but in ship-building, the outside plating, the deck-plating, stringers, ties, keelsons, etc. etc., can only be riveted-up in place, and under conditions which do away with much of the advantage otherwise obtainable from the use of machines.

There are three common forms of rivet-points—the *countersunk* (Fig. 40, Vol. III., page 351), used where a flush surface is required; the *snap* (A, Fig. 58), used for inside work, beams, bulk, heads, keelsons, etc., where it is unnecessary to make flush surfaces; and the *conical* (B, Fig. 58), sometimes used instead of the snap-point, but more commonly employed in boiler-making than in ship-building. The first and third points can be formed with hand-hammers only by the riveters; the second requires the use of a cup-shaped die, in order to give it the finished hemispherical form, this die being driven over the point after it has been roughly formed.

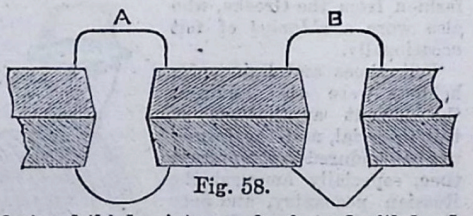


Fig. 58.

From the preceding remarks it will be obvious that the iron from which rivets are made needs to be of very superior quality, in order that it may successfully withstand the manipulation of manufacture and knocking down the point. Lowmoor, Bowling, and other Yorkshire irons are largely used for rivets, but not to the exclusion of other makes. Steel rivets have been also used, but they require very careful treatment, and are not to be depended on so thoroughly as iron rivets; for which reason it is generally considered preferable to use the latter, even in steel-plated ships.

Rivet-holes are almost always punched in plates and bars, the more expensive operation of drilling being had recourse to only in special cases. In a previous paper it was remarked that the

* Chap. XVII., on "Rivets and Rivet-work," gives most of the best experimental results hitherto published, including those obtained in the Royal dockyards. From it we draw most of the data used in our treatment of this question.

strength of a plate of iron was reduced somewhat by punching. Mr. Reed states that this reduction may be taken as about four tons per square inch of sectional area for iron, which would, when unpunched, stand a tensile strain of twenty-two tons per square inch, supposing the plate to be perforated by a row of holes such as would commonly be required for butt-fastenings. With steel the reduction in strength produced by punching is still more considerable, and it is considered advisable either to drill the holes or to anneal the plates after the holes are punched, in order to avoid this disadvantage. The gain in rapidity and cost of workmanship due to punching as compared with drilling, leads, however, to the continuance of the former method, which has, besides, the advantage of giving a slight countersink, or conical form, to the hole, as explained in page 351, Vol. III. We would also refer the reader to the remarks there made respecting the necessity for care in determining the side *from* which holes should be punched in plates.

Turning next to the relation existing between the thickness of plating and the diameters of rivets used, we will first of all give a tabular statement showing the practice of the private yards, as represented by Lloyd's rules, and that of the Royal dockyards, as stated by Mr. Reed. The thickness of plates and diameter of rivets are in sixteenths of an inch.

THICKNESSES OF PLATES.	DIA. OF RIVETS.		THICKNESSES OF PLATES.	DIA. OF RIVETS.	
	Lloyd's	Gov. Serv.		Lloyd's	Gov. Serv.
5 . . .	10	8	11 . . .	14	14
6 . . .	10	10	12 . . .	14	16
7 . . .	10	12	13 . . .	14	16
8 . . .	12	12	14 . . .	16	18
9 . . .	12	14	15 . . .	16	18
10 . . .	12	14	16 . . .	16	18

It will be observed that in no case is the diameter of the rivet less than the thickness of the plate; and it is found in practice very difficult to *punch* a hole of less diameter than the thickness, nor is it desirable to do so in most cases, although, when required, smaller holes can be drilled. In no case, also, is the rivet's diameter greater than twice the thickness of the plates—an upper limit which experiment and investigation agree in fixing. The table holds good for two thicknesses of plating, or a plate and a bar; if three thicknesses are to be fastened, the diameter of the rivet is usually made a little greater. The diameter of the rivet is also generally estimated from the thickest piece in a combination. The holes in the plates are punched a little larger (about one-sixteenth of an inch) than the diameter of the rivets, so that when heated and expanded they may be easily introduced into the holes. All these are practical details which experience has proved to be of considerable importance, and respecting which ship-builders do not differ materially.

Experience has also had most to do with the determination of the proper spacing or "pitch" of rivets in various descriptions of work. When joints are to be caulked and made water-tight, the pitch, or distance from centre to centre, of the rivets should not exceed from four to five diameters in the rows adjacent to the joints; but when it is a question merely of connection between plates and stiffeners—as between the outside plating and the frames, or the deck-plating and the beams—then the pitch may be made about twice as great—say from seven to nine diameters. There are, however, other questions in connection with the pitch of rivets, particularly as regards butt-fastenings, which are by no means free from difficulty or discussion; and hereafter we shall refer to them more fully.

Experiments have been made to determine the tensile strength of rivet-iron, and also its *shearing* strength—*i.e.*, the force required to cut the iron across at a section perpendicular to the length of the bar. It appears that the shearing strength is a little less than the tensile strength; but this fact is not of any great practical value in making arrangements of riveting, because it is well established that the iron in the finished rivet is less strong than that in the bar—having suffered somewhat from the usage to which it is subjected in its manufacture, knocking-down and cooling—and also because of the fact that the contraction of the rivets in cooling necessarily causes considerable friction in a joint, and so adds to its strength to resist tensile strains. Our meaning will be more clearly understood if we suppose the tie-plate shown in Fig. 10 (Vol. III., page 30) to be subjected to tensile strains, tending to tear the butt asunder. If instead of finished rivets in the butt-strap we had merely pegs of rivet-iron passed through the holes, and were careful to keep the straining force exactly in the line of the tie-plate, then it would only be necessary to shear off these pegs, in order to open the butt. But when finished rivets are put in, friction is caused by their contraction at the surfaces of the strap and plate, and then in order to open the butt it is necessary to overcome this friction, as well as to shear off the rivets. The shearing strength of the rivets would no doubt be less than that of the supposed pegs of rivet-iron; but taking into account the friction, the strength of the butt would be increased. In practice we do not require to separate the frictional resistance from the shearing strength of the rivets, but rather need to know something definite as to the strength of riveted joints, with finished rivets. Mr. Reed supplies us with some facts which exactly meet this necessity, stating, as the result of experiments made at Chatham Dockyard, that the "mean shearing strength of a $\frac{3}{4}$-inch rivet passing through two plates was ten tons, and the mean of the double shearing strengths of a $\frac{3}{4}$-inch rivet passing through three thicknesses was about eighteen tons." These experiments were made under fair representative conditions as to pitch of rivets, breadths of lap, etc., and form reliable data for calculation. It is probably near the truth to assume that for finished rivets of other sizes the strengths would compare with that of the $\frac{3}{4}$-inch rivet as the *squares of the diameters* compare; for example, that for a 1-inch rivet:—

For single shear—

Strength : 10 tons : : $(1)^2 : (\frac{3}{4})^2$;

Whence—

Strength $= \frac{160}{9} = 17\frac{7}{9}$ tons.

And for a double shear—

Strength : 18 tons : : $(1)^2 : (\frac{3}{4})^2$;

Whence—

Strength : 32 tons.

It will perhaps be worth adding that a simple illustration of what is meant by a *double shear* may be obtained by supposing that a second butt-strap is fitted above the plate-tie in Fig. 10 (Vol. III., page 30). Before the butt could then be opened, the parts of the rivets lying between the straps would have to be dragged away with the plates, and so there would be a *double* shear. Hereafter we shall see how valuable a method this double strapping is in securing the butts of some pieces of an iron ship.

Before concluding this article, we would draw attention to a simple but important fact, which has an important bearing upon the proper arrangement of butt-fastenings in an iron ship—viz., that in all cases the pieces butted have unavoidably weakened sections, the strength of which should regulate that of the butt-fastenings. For example, if we take the simple case of a deck stringer-plate (similar to that shown in Fig. 56, page 37), we find rows of holes punched to receive the rivets securing the stringer to the beams, and in wake of these holes weakened sections must occur. Or if we turn to any assemblage of plating, such as the outer skin, we find similar weakened sections existing in wake of the transverse frames and stiffeners. These weakened sections might, of course, be made stronger by means of broad liners; but this plan would lead to costly workmanship, and does not recommend itself for adoption, except in special cases, such as in wake of water-tight bulkheads. Ordinarily, stringers, ties, and assemblages of plating are left without additional strengthening at the weakened sections in wake of the stiffening pieces, frames, beams, vertical and horizontal bars, etc., and as a consequence it is only necessary to give to the sections in wake of the butts an amount of strength equal to that of these weakened sections. If more strength is given, an additional and useless expenditure of money, time, and material is incurred, and it is folly to attempt to make the strength in wake of the butts as great as that at sections where the plating is left unpunched.

Stress is laid upon these considerations, because, simple as they are, they have been overlooked by some persons who have done much to advance wrought-iron construction; and as a result, deductions made from experiments on simple plate-ties (such as are illustrated by Figs. 9 and 10, Vol. III., page 30) have been applied, without correction, to the very different combinations of plating in the structure of an iron ship. Heavy and expensive arrangements of butt-fastenings have come into use in consequence; but such fastenings are worse than useless, and the fact is now very generally acknowledged.

FORTIFICATION.—XII.

By An Officer of the Royal Engineers.

TYPES OF PERMANENT DEFENCES—BASTIONED SYSTEM—POLYGONAL SYSTEM—FORTIFICATIONS OF ANTWERP.

Anything like a thorough investigation of the various systems of permanent fortification still existing in Europe would be a work of considerable time and labour, without having for the generality of students any practical advantage. Many of these systems are now obsolete, and were designed for warfare under totally different conditions to those of the present day; there is, therefore, little beyond a certain historical interest attaching to them, and they will only be referred to in order to explain the uses of such of their details as may still be retained in the more recently constructed European fortresses.

We find that the types of permanent defences have succeeded one another at longer or shorter intervals as the science of artillery progressed and the occasion for building fortresses occurred.

Thus, during the wars of France in the sixteenth and seventeenth centuries, when a large number of towns were strengthened and besieged, the systems previously employed were considerably extended and improved; and again after 1815, when the Germans had occasion to strengthen their frontier, they sought to avoid the defects of the bastioned system by adopting the suggestions of Montalembert, and thus entirely changed the type of their works. Prior to the introduction of artillery, the main enclosure or *enceinte* of a fortress consisted of a high masonry wall, high enough to be secured from escalade, and sufficiently thick to resist the action of battering rams and other engines employed in the sieges of that period. The fighting of the defenders was carried on behind a loopholed parapet at the top of this wall, which was flanked by towers placed within bow-shot of one another. These towers were originally round or square in plan, and of no very great size, but under the new conditions it became necessary to make them larger, so as to allow of parapets being constructed of earth instead of masonry, and they were placed further apart to suit the increased range of fire-arms.

The Italian engineers, as early as 1530, adopted the pentagonal or bastion shape for these towers, from the facility they afforded for reciprocal flank defence, and hence arose the various systems known as bastioned systems, which underwent various modifications at the hands of Vauban (1650), Cormontaigne, and other celebrated engineers, and are now to be found in all the French and in numerous other Continental fortresses. The system of fortification which has, however, lately become the favourite type, as being most adapted to the changed conditions of war, was, strange to say, advocated as early as 1527, in a work on fortification by Albert Durer, at Nuremburg, as well as by Martini, an Italian, about the same date. It was first adopted in Germany early in the present century, and has subsequently been employed in Belgium, and in the more recently constructed forts for the protection of the English dockyards.

The chief characteristics of this system of fortification, which is called the "polygonal system," are, that the lines of parapet are traced with reference to the space they have to enclose, and the direction from which it is probable an attack would be made, and not with reference to the reciprocal flank defence of the ditches, which are entirely defended by casemated masonry buildings in them, called kaponiers, or by reverse galleries placed in the counterscarps at the salients.

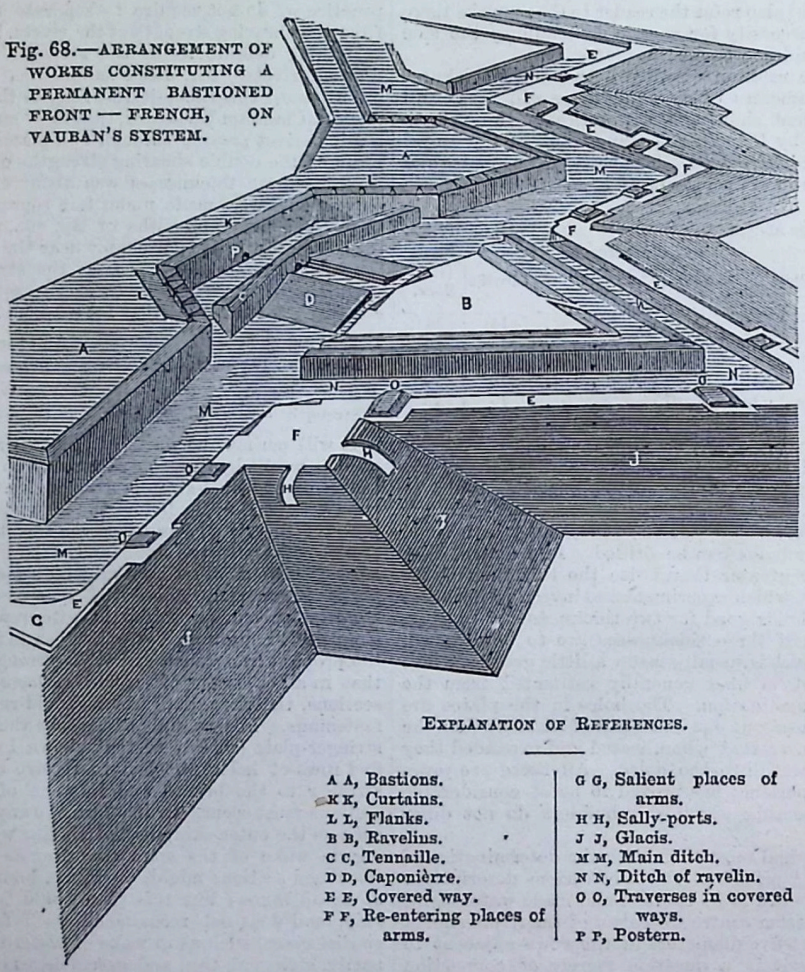


Fig. 68.—Arrangement of works constituting a permanent bastioned front — French, on Vauban's system.

Explanation of References.

A A, Bastions.
K K, Curtains.
L L, Flanks.
B B, Ravelins.
C C, Tennaille.
D D, Caponière.
E E, Covered way.
F F, Re-entering places of arms.
G G, Salient places of arms.
H H, Sally-ports.
J J, Glacis.
M M, Main ditch.
N N, Ditch of ravelin.
O O, Traverses in covered ways.
P P, Postern.

There are various minor differences, both as regards the profile and the arrangements of the outworks, which exist between the two systems, and which will be referred to hereafter; but before examining these details, the names and uses of the following portions of a permanent fortress should be understood:—

The *enceinte*, or "body of the place," is the main enclosure of the fortress, and usually consists of an earthen embankment or "rampart," and a deep ditch with a revetted escarp and counterscarp.

The *rampart* should be of sufficient height to enable the guns on it to thoroughly command the whole of the ground within range, and wide enough to carry a parapet at least twenty-five feet thick, as well as allowing ample room for working the guns and the other operations of the defence.

The *ditch* of a permanent work provides the earth to form the rampart, and must in itself be a formidable obstacle. In low, marshy sites, the ditches are usually filled with water, and are made of considerable width, but not more than ten or twelve feet deep, which is sufficient to oblige the enemy to construct rafts or bridges to cross them. In other positions where water is not found near the surface, the ditches will be dry, and must be of such depth, that even with the use of long scaling ladders the operation of crossing them is very difficult and slow, while the breadth must allow of their being flanked by a battery of several guns. So long as this last condition is fulfilled, it may safely be affirmed that the deeper and narrower a dry ditch is, the stronger the work will be, as the escarps will be better covered and the difficulty of escalade greatly increased. As a rule, wet ditches are not revetted, whereas dry ditches are, and the heavy expense of revetment walls is saved in cases where the former can be employed. In some situations—as, for instance, where a river flows through a fortress—it is possible to combine the advantages of both wet and dry ditches without the defects of either. This is managed by means of sluice-gates, which enable

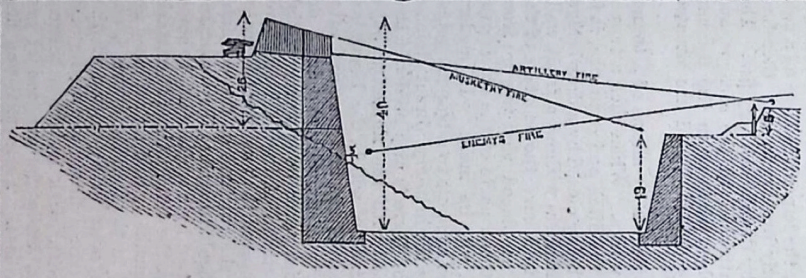


Fig. 69.—SECTION THROUGH BASTIONS OF VAUBAN'S FIRST SYSTEM, SHOWING THE LIABILITY TO BE BREACHED BY ENEMY'S ARTILLERY.

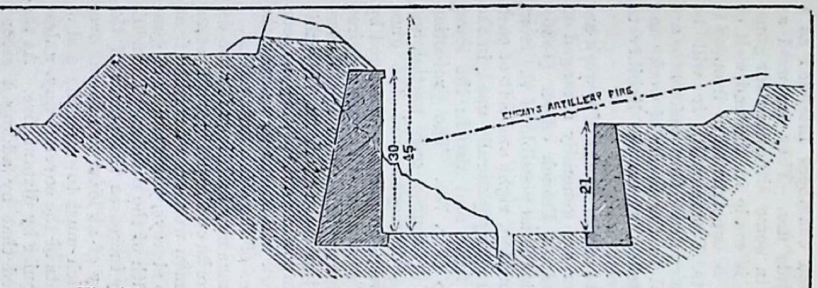


Fig. 70.—SECTION THROUGH BASTION IN MODERN FRENCH SYSTEM.

Fig. 73.—SKETCH SHOWING ARRANGEMENT OF WORKS ON A FRONT OF THE GERMAN POLYGONAL SYSTEM.

EXPLANATION OF REFERENCES IN FIG. 73.

A A, Body of the place.
B B, Casemated flanks to defend ditch of kaponier.
C, Casemated kaponier, two tiers of 5 guns.
D, Ravelin.
E E, Casemated flanks to defend ditch of ravelin.
F F, Casements in ravelins to defend ditch of counter-guard.
G G, Counter-guard.
H H, Covered way.
J J, Glacis.
K, At the salients of the covered way there are often masonry block-houses flanking it, and acting as a traverse.

Extent and Position of the Enemy's Batteries.

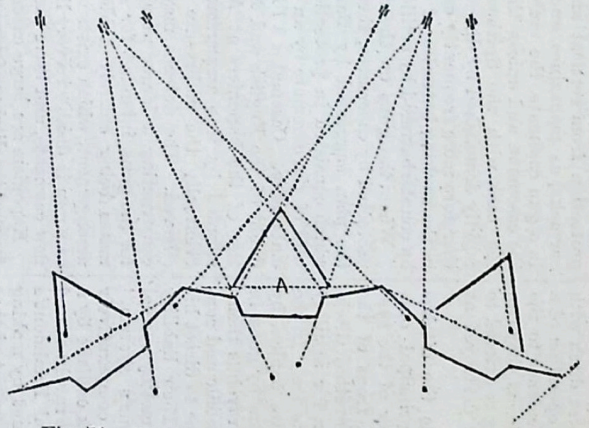


Fig. 71.—SKETCH SHOWING LIABILITY TO ENFILADE IN THE BASTION SYSTEM.

Extent of Enemy's Position necessary for attacking the Front A in the Bastioned System.

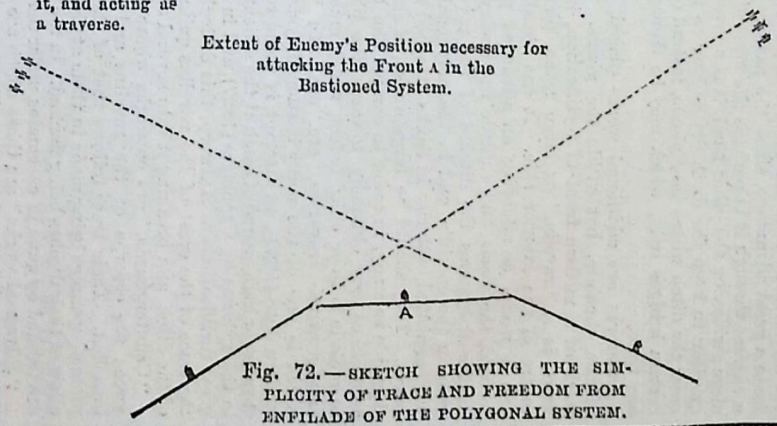


Fig. 72.—SKETCH SHOWING THE SIMPLICITY OF TRACE AND FREEDOM FROM ENFILADE OF THE POLYGONAL SYSTEM.

the defender to flood his ditches at pleasure, and gives the defence a great advantage, since the passage of a wet ditch with a current through it is perhaps the most difficult operation of a siege; while, on the other hand, it is a great convenience to the garrison to keep the ditch dry as long as possible, as they can cross the ditch where they please, instead of being restricted to certain bridges only, which may be damaged or destroyed at any time.

Outworks are additional works placed outside the ditches of the enceinte, but within the glacis. The principal outwork of a modern front of fortification, in either of the systems, is a "ravelin," or large redan, placed in front of the centre of the exterior side. It has usually a revetted ditch, and is useful as affording an advanced position for artillery to flank the glacis and enfilade the enemy's trenches. In the bastioned systems the ditches of the ravelins are flanked by guns in the enceinte, and in the polygonal system by guns in low casemated batteries in flanks attached to the ravelins themselves. They should be large works, of strong profile and considerable saliency, in order to compel the besieger to direct his approaches very obliquely towards the place. Their liability to enfilade is their chief defect, which must be met by special arrangements—traverses, etc. etc. In "Dufour's system," which is one of the many bastioned systems of comparatively modern date (1822), an attempt is made to check enfilade by a cavalier or high mound of earth at the salient of the ravelins; and in the systems by Choumara (1827), and in General Brialmont's great fortifications at Antwerp, this difficulty is met by making the trace of the crest of the ravelins quite independent of that of the ditch, and breaking it into several short faces.

"Counterguards" are outworks whose primary object is to screen the escarps of the ravelins and enceinte from being breached. Their trace follows that of the works they have to protect, openings being made in them at the re-entering angles to allow of their ditches being flanked. In the German systems they are flanked by guns in casemates under the faces of the ravelins.

"Advanced works" are those which are occasionally added to the ordinary works of a permanent front to ensure the defence of ground which would not otherwise be brought under fire. They are usually open works beyond the glacis, but within easy range of the guns in the enceinte. Horn works and crown works belong to this class, and may be found in many of the older fortresses.

"Retrenchments" are works constructed within others with a view to isolate the parts most liable to be first taken, and thus prolong the defence of the fortress. In the bastioned systems retrenchments are extensively provided, both in the bastions of the enceinte and in the ravelins, portions of the faces of which are isolated by a small ditch and parapet at right angles to the face, called a *coupure*.

An outwork termed the "redoubt of the ravelin" exists in most of the bastioned systems. It is a small lunette within, but separated from the ravelin by a ditch, and serves as a species of retrenchment to it as well as being useful in bringing a reverse fire to bear on that portion of the bastion face most likely to be breached.

A "cavalier" is a high work having sufficient command to allow its guns to fire simultaneously with those of the works in front, and to bring a plunging fire to bear on the enemy's lodgments on the glacis. A cavalier frequently is made to contain a bomb-proof barrack or principal magazine, and when isolated from the rest of the works by a ditch, is often made use of as a retrenchment.

Bastions are termed "full" when the interior is level with the terre-plein of the rampart on either side of it. Empty bastions are those in which the interior is at a lower level than the ramparts. These latter have the defect that the space available for constructing traverses, parados, etc., during a siege, is much more cramped than in the others.

The "covered way" is a passage usually about eleven yards in width between the glacis and the edge of the counterscarp. It is about eight feet below the crest of the glacis, and is provided with a banquette for musketry, and with traverses to check enfilade. It serves as a useful means of communication between various parts of the works beyond the ditch, enables the defenders to assemble in numbers before making sorties, and by giving cover to the advanced sentries affords great security against surprise.

Casemates are arched bomb-proof chambers intended as a protection from vertical and enfilade fire. They are used as barracks, as magazines, and also in some situations for guns. In a gun casemate, the embrasure is made in the end wall of the casement, and unless this wall is constructed of iron (as is the case with the Spithead Forts, Portsmouth), it will be rapidly demolished by direct artillery fire. Gun casemates are therefore more frequently employed in the flanks of works and in the flanking batteries of the ditches, where the liability to be counterbattered by artillery is remote.

When the guns on the ramparts of the flanks of a work are protected by casemates, these latter are generally arranged on the plan suggested by Baron Haxo, a French officer (1826), which consisted in protecting as much as possible of the front wall of the casemate by an earth merlon, right and left of each embrasure. Casemates à l'Haxo are very generally used in the flanks of the English and Belgian forts, and also in the lower tier of the kaponiers at Antwerp (Fig. 78). The protection afforded by this arrangement is, of course, only partial, and eventually the embrasure will be destroyed and the guns silenced. The defence may, however, be greatly prolonged by constructing a larger number of casemates than are required for the guns intended for simultaneous firing, the spare casemates being entirely hidden by the earth merlons. By this arrangement, which exists in the kaponiers at Antwerp, as soon as a gun is disabled a very little work will suffice to unmask the new casemate, and leave the defence of the ditch unimpaired.

Kaponiers are large casemated masonry buildings for the defence of the ditches of permanent works on the polygonal system. The ones generally seen in the German works are detached from the escarps and constructed in two storeys, the number of guns in each tier depending on the breadth of the ditches. The addition of a second gun-floor greatly increases the power of the kaponier, and gives it a superiority of at least two to one over the enemy's counter-batteries, which must towards the end of the siege be erected near the salients of the covered way, unless they are able to silence the kaponier by distant fire. At the same time it must be remembered that by adding a second storey to the kaponier, the amount of exposed masonry is greatly increased, and it becomes almost impossible to protect it from the effects of curved fire. In the detached forts that have been constructed in England, the kaponiers have as a rule only one gun-floor, and consequently are lower, and therefore much less liable to be damaged by distant artillery fire. The English kaponiers are generally attached to the escarps, and placed at the angles of the ditches, whereas in the German works the kaponiers are generally detached, and are situated in the middle of each long face.

The communication to the kaponiers is by means of a tunnel leading from the interior of the works. When such a tunnel serves as the means of access to the ditch and outworks, it is called a postern, the entrance to it being closed by a drawbridge.

Mortar casemates are vaulted chambers without a front wall, employed in many modern works to secure the mortars of the fortresses from vertical fire, and so placed that the fire from them can be brought to bear on those parts of the glacis over which the advance of the attack will be made. In modern sieges there is little doubt that the attempt to advance against a place must be disastrous, unless the artillery direct defence has been previously annihilated, and there is also no doubt that in time this result will be obtained with the numerical superiority of guns, and the concentrated fire which the besieger is able to oppose to the smaller front of the besieged, and after the attack has once established its supremacy, any fresh development of artillery defence must needs be but very partial, and easy to be silenced by a repetition of the first bombardment. It is under these circumstances that mortar casemates are of great use. Placed behind the rampart of the enceinte, unseen by the enemy, and very difficult to strike, they command the field of attack at the salients, and by a well-directed shower of large shells must greatly increase the difficulties of the attack, which would otherwise only have musketry and mitrailleuse fire to deal with. They are employed in the German systems, and in some of the English forts. It is, however, a question whether the protection afforded against vertical fire is worth the cost, since mortars in these positions with earth traverses between them would be nearly as efficient, while the expense of preparing for them would be much less. Their use was first

advocated by Virgin, a Swedish engineer, in 1780, and subsequently by Carnot.

A *tennaille* is an outwork in front of the curtains of the bastioned systems, and is given as a parapet for the musketry defence of the ditch. Its chief use, however, is to act as a counter-guard, and protect the postern and escarps of the curtain and flanks from being breached. In works with dry ditches it facilitates sorties against the besiegers at the moment they are trying to assault and storm the breach, as the defenders can assemble in considerable numbers in the space between the tennaille and curtain.

A *caponnière* is a low work consisting of two glacis parapets, which serve to cover the communication across the main ditch between the tennaille and the ravelin of a bastioned front.

The terms "salients" and "re-entering places" of arms are given to the enlargements of the covered way, which are made at the angles formed by the ditches. The re-entering places of arms are useful, as affording space for assembling troops for making sorties, and points from whence the possession of the covered way may be disputed. In Vauban's first system a traverse is placed on either side of the re-entering place of arms, which converts it into a species of redoubt; and in almost all the other bastioned systems this idea is still further carried out, the re-entering place of arms being made larger, to admit a regular redoubt with a ditch being constructed within it.

The names and uses of the principal parts of a fortress having now been mentioned, we must consider what conditions the profile of a permanent work should fulfil, and how far they are carried out in the two main systems under consideration.

1st. The glacis of the fortress should be swept by both the artillery and musketry fire, and, moreover, the latter should be able to thoroughly command the covered way and interior of the outworks. To effect this, the musketry fire is usually arranged so as to strike a point about three feet above the top of the counterscarp.

2nd. The ditch should be a really formidable obstacle, which, in dry ditches, implies a counterscarp of twenty feet, and an escarp thirty feet high, the width of the ditch being dependent on the flanking arrangement and the fulfilment of the last condition.

3rd. The escarp must be screened not only from view, but also from the enemy's fire. Where the flanking defences have been silenced, and the approaches of the attack have arrived at the crest of the covered way, the escarp is (in a dry ditch) the only serious obstacle in the way, as the counterscarp wall can in a short time be blown in by mining, and the assaulting troops admitted to the ditch of the fortress.

The accurate curved fire and large shells of the present day give such facilities for breaching a wall from a distance, that not only must the ditches be made narrower than heretofore, but deeper, so that the top of the escarp wall shall be some ten or fifteen feet lower than the crest of the glacis. This plan has been adopted in the profile of the English forts, and the tendency towards this may be observed by noticing the difference between the profile of the earlier works (Vauban, Fig. 69), the subsequently improved profile of the modern French system (Fig. 70), and that of the English works (Fig. 76).

The escarp wall of a fortress must necessarily be high, massive, well built, of very considerable length, and therefore a very expensive item. It may either be attached to the rampart, and serve as a revetment to the earth behind it, or may be a detached wall, as in the German system (Fig. 73). A detached escarp is sometimes called a "Carnot wall," from the name of the French officer who proposed its adoption about 1810. Escarp revetments are termed "full" when the masonry is carried up to the superior slope. "Demi-revetments" are those in which the top of the masonry is at the level of the berm or foot of the exterior slope. "Chemin des rondes" is a demi-revetment advanced a sufficient distance in the front of the foot of the exterior slope to allow a passage between it and the slope. This has many advantages. 1st. If the upper part of the escarp is breached, it does not necessarily bring down with it the earth from the parapet. 2nd. A secure place for sentries is provided from whence they can see into the ditch, and prevent a surprise. 3rd. From it an additional line of musketry defence can be brought to bear on the enemy in the covered way and ditch, and during the siege working parties can assemble in it, and repair the damages done to the slopes. A small parapet wall is usually added to the ordinary demi-revetment wall (*vide* Fig. 75) in a "chemin des rondes." Escarp walls are either built solid or in a series of arches, the fronts of which are built up to hide the position of the piers. In the former case they may be either "leaning"—*i.e.*, when both front and back of the wall slope inwards towards the parapet; "sloping," in which case the only front of the wall is built at a batter or inclination; "counter-sloping," where the front of the wall is vertical, and the back of it slopes from a broad base to a minimum thickness at the top. The wall suffers less from the action of the water, and the growth of weeds in the joints of the masonry, when built with a vertical than with a sloping face: hence counter-sloping revetments are preferred.

In counter-arched revetments the earth is carried on the arches, and its lateral thrust against the wall is avoided. The arches are usually in two tiers, the space beneath them being sometimes converted into a gallery with loopholes through the escarp for musketry fire. Such galleries are termed escarp or counterscarp galleries, and are frequently employed in both the German and English works as a means of flanking the kaponiers and defending the ditch.

As regards safety from breaching, the detached wall in the German system has an advantage, as without altering the width of the ditch or the relative levels, it can be better protected by placing it nearer to the counterscarp; whereas in the bastioned systems, the escarp must follow the outline of the rampart, and the ditch must either be reduced in width or the glacis raised considerably, which would probably involve an increased command to enable the guns on the terre-plein of the rampart to defend the ground outside.

The general idea of the works of a front as arranged by Vauban is given in Fig. 69, and although the actual dimensions he adopted were designed for the fire-arms of 1650 and are now obsolete, yet the main arrangements of his system have been retained, and form the basis of all the modern French systems which may be seen at Paris, Metz, Lille, etc. etc.

The improvements that have been made on the original type consist, as regards trace, in—

1st. Larger and more salient ravelins, large enough to admit an inner redoubt.

2nd. Better flanking angles for the bastions of the enceinte.

3rd. Redoubts in the re-entering places of arms.

4th. Escarps of bastions better covered, by making the ditches of the ravelins shallower, and constructing traverses across them. These traverses are also of use in covering the communication to the covered way.

5th. Redoubts in the re-entering places of arms, and coupures in the ravelins.

The improvement in profile from the "full" to the "demi" or the "chemin des rondes" revetment has been already alluded to.

One of the most important defects of the bastioned systems, as compared with the polygonal trace, is the liability of the former to suffer from enfilade and reverse fire. In the present day, when elongated rifled shot do not ricochet with such certainty along the line of fire as the old spherical projectiles, the effect of enfilade fire may be less than formerly; but if so, the power of shells has on the other hand greatly increased, and the disadvantage to the defenders of works so traced as to be liable to enfilade or reverse fire will be keenly felt.

The bastions of Forts Issy and Vanves in Paris, and some of the bastions of the Paris enceinte suffered in this way, and one has only to glance at the complication of traverses that were thrown up in the hopes of checking this, to be quite certain of this grave defect inherent in the system. In Fig. 72 the advantages possessed by the more simple trace of the polygonal over the bastioned trace are shown.

Fig. 73 gives a general idea of the arrangement of works usually adopted in the German fortresses. It must not, however, be supposed that this exact combination is to be found in every case, for though built on the same principles, there are so many details dependent on the site, and also on the finances at the engineer's disposal at the time, that very few fronts and certainly no two fortresses will be found exactly similar.

The head of the kaponier is flanked by casemates in the escarp of the enceinte, while the ditches of the ravelins and counter-guards are defended by similar casemates in the ravelin. Mortar casemates and bomb-proof cover generally are also a distinguishing feature of the system, as is the detached or semi-detached loopholed escarp wall already alluded to. This wall

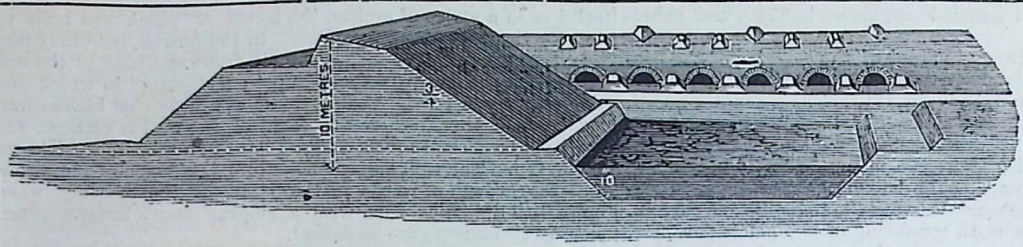


Fig. 78.—SECTION THROUGH ENCEINTE AT ANTWERP, SHOWING MAIN KAPONIER.

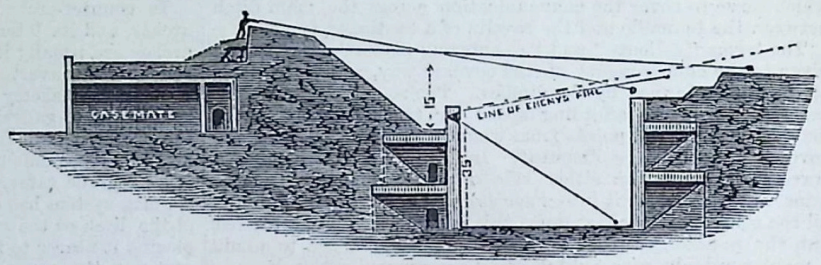
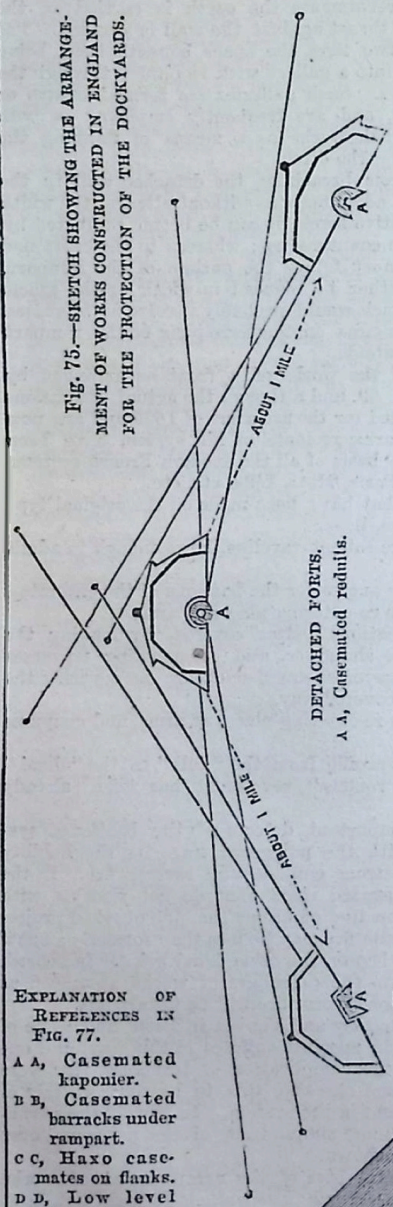


Fig. 76.—TYPE OF THE SECTION ADOPTED IN ENGLAND—COUNTER-ARCHED REVETMENTS AND CHEMIN DES RONDES.

Fig. 75.—SKETCH SHOWING THE ARRANGEMENT OF WORKS CONSTRUCTED IN ENGLAND FOR THE PROTECTION OF THE DOCKYARDS.



DETACHED FORTS.
A A, Casemated redoubts.

Fig. 74.—GERMAN SYSTEM—DETACHED ESCARP WALL AND COUNTERSCARP GALLERIES.

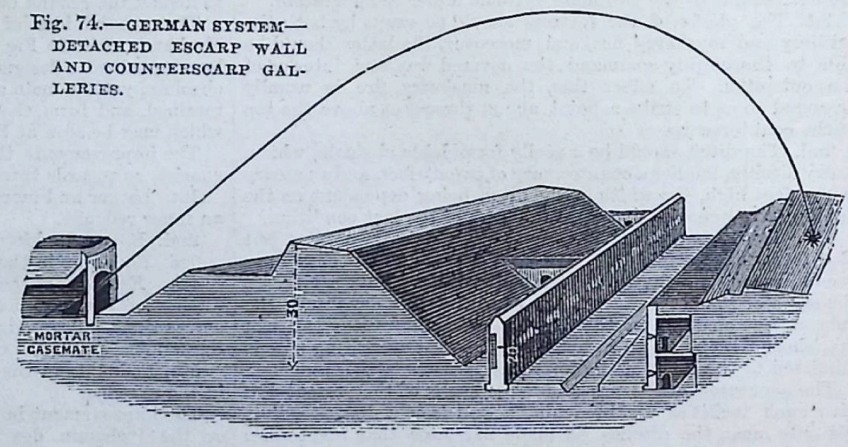
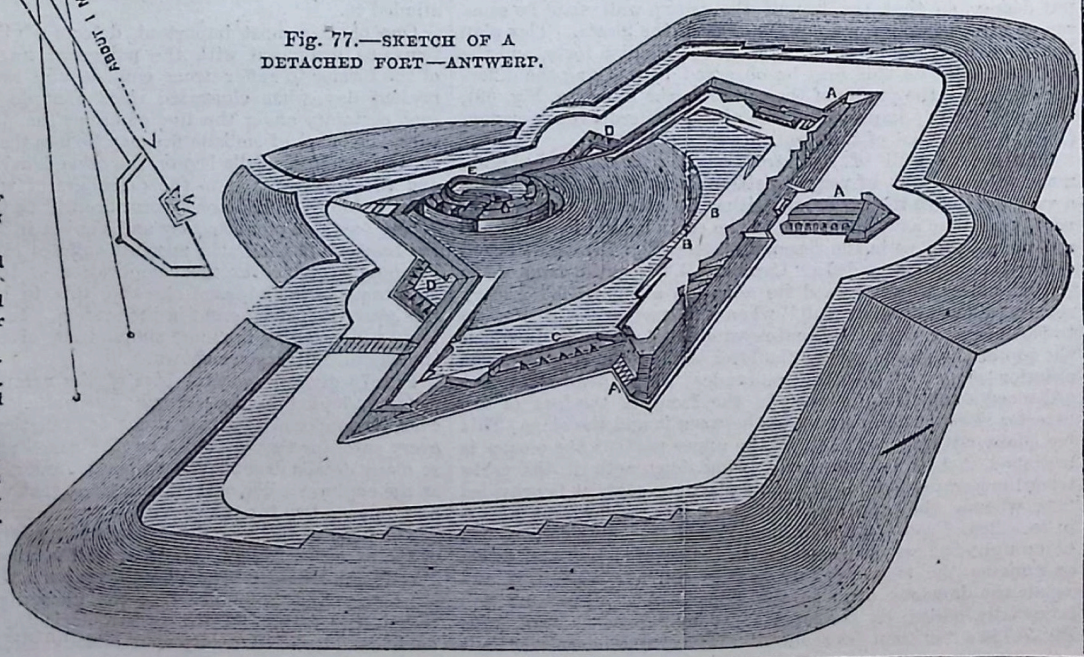


Fig. 77.—SKETCH OF A DETACHED FORT—ANTWERP.



EXPLANATION OF REFERENCES IN FIG. 77.

A A, Casemated kaponier.
B B, Casemated barracks under rampart.
C C, Haxo casemates on flanks.
D D, Low level batteries.
E, Casemated reduit, surmounted in some cases by an iron turret for two guns.

secures the place against surprise, brings a close fire on the bottom of the ditch, and when breached does not bring down with it a large mass of earth to block up the ditch and impede the fire from the flanks and kaponiers. Wrought-iron palisades or high railings have been proposed of late years in Germany as a substitute for this wall.

In England there are very few fortresses or fortifications of any kind except mere coast batteries, and the newly-constructed detached forts at our principal naval dockyards. In arranging the defence of the dockyards, the two antagonistic conditions of a long line to defend, and a minimum number of defenders, had to be reconciled. An enemy having once landed in England, the whole of the regular troops, as well as a large body of militia, would be required for the field army, and the defence of the dockyards would devolve upon a relatively small number of reserves, and on the garrison and marine artillery. The object of the works is to prevent the enemy either taking them easily or passing between them, and at the same time to render it impossible for him to burn the dockyards by a distant bombardment. The enormous range of rifled guns obliged the circle on which the guns are placed to be a very large one, with a radius of not less than 4,000 or 5,000 yards, and the necessity of preventing an enemy in force passing between them rendered it advisable to place them within easy artillery range of one another. The works are thus mutually supporting, and form as it were a series of closed bastions, no one of which can be attacked without engaging two or more collateral forts. The intervals between the forts can easily be further strengthened by batteries and field-works placed somewhat in rear of the main line. As compared with Continental examples of detached forts, they are small, being intended for defence by small bodies of troops; their profile, however, is a formidable one, calculated to enable them to make an obstinate resistance (Fig. 76).

The independent trace of the parapets and ditches, kaponier defence, Haxo casemates in the flanks, considerable casemated accommodation, and a casemated keep or "reduit" serving as barrack in time of peace, form the chief characteristic of the English detached forts.

The magnificent new fortifications of Antwerp are probably the most complete and interesting modern works in Europe. A level site, and an almost unlimited vote, have enabled General Brialmont to construct a most formidable and extensive enceinte, strengthened by a circle of detached forts at a distance of about 2,000 mètres in front. This combination of a continuous enceinte with a cordon of forts is undoubtedly the strongest type of defence, if it can be carried out on a sufficiently large scale, and may be found at Paris, Metz, Lyons, Cologne, Coblentz, Mayence, and other first-class fortresses. The object of the forts is to prevent or postpone the bombardment until after they are taken, after which the regular siege would begin while the enceinte would prevent the enemy forcing his way through, and investing or cutting off each fort from its supplies, etc. At Antwerp, the ease with which a large extent of the surrounding country can be inundated, and the distance of the enceinte from the town, render it an exceptional case, in which the character of the site has been fully taken advantage of, and in which both the principles and details of the polygonal system, as adapted to modern requirements, have been most admirably applied. The section of both the enceinte and detached forts is very similar (Fig. 78). The detached forts themselves, of which Fig. 77 gives a general idea, are much larger than the corresponding works in England, and are connected by a military road under cover of a parapet. Batteries are intended to be constructed in the intervals between the forts, and both a railway and telegraph would be employed to facilitate communications between them.

The experience of the late war has shown that if fortresses are to be of any real importance in future, they must be completely armed, provisioned, and adapted to modern warfare, not merely capable of resisting for a certain time on the front attacked, but of withstanding the heaviest bombardments. To do this bomb-proof cover in immense extent must be provided, far in excess of the peace requirements of the garrison, and no buildings on any account whatever should be allowed near the works. Buildings, however small, within 2,000 yards of the works, would, if in front, have to be pulled down, and even then their ruins would give cover, and if behind the forts, they are sure to draw on their inhabitants the horrors of a bombardment. Were it possible to obtain it, a model fortress should contain no buildings that could suffer from the enemy's fire, nor a population of any but soldiers for its defence, and in future sieges the most humane governor of a fortress will be the one who has the courage to ruthlessly expel the whole non-combatant population before the siege begins, rather than he who, out of compassion for their helplessness, allows them to remain and ultimately become the victims of famine and bombardments. The Russian fortress of Modlin, near Warsaw, is perhaps the nearest approach to this type in Europe.

The study of permanent fortification is a deep and complicated one, and it has, therefore, been impossible to do more than treat it here in a very superficial manner. The best books on the subject are, perhaps, "History of Fortification" (German) by Zastrow; "Défense des États," by General Brialmont; and numerous works in French by Noizet de St. Paul, Bousmard, Chasseloup de Laubat, Montalembert, Haxo, Choumara, etc.; while the works in English by Sir H. Douglas on "Modern Systems of Fortification," by Captain Philips, R.E., Captains Lendy and Straith, as well as numerous articles on the subject, which have appeared in the Royal Engineers Professional Papers, should be studied by any one anxious to master the subject.

PATENTS AND PATENT LAW.—IV.

By A Barrister.

THE RIGHTS AND PRIVILEGES OF A PATENTEE.

Having obtained a patent, what rights become vested in the patentee? Several provisions of great importance have been introduced into the various Acts of Parliament for the purpose of protecting patentees. And, first, to protect them in the possession of their patent it is provided that if, after a patent has been granted to a person on the ground of his being the first inventor, it is discovered that some other person had in fact preceded him in the use of the invention, though the article was, at the time of the grant, not generally known to the public, the acts enable the patentee or his assigns to petition Her Majesty in Council for a new grant, or a confirmation of the existing one; and if the Judicial Committee of the Privy Council shall, upon investigation of the case, report in his favour, such relief may be lawfully awarded (5 & 6 Wm. IV., c. 83, s. 2). And we have already referred to the process of disclaimer by which any error in the title or specification may be rectified.

The actual rights and privileges which the patentee possesses under the letters patent will be best understood by a reference to the form of the letters patent, which runs thus:—"Know ye therefore that we, of our especial grace, certain knowledge, and mere motion, have given and granted, and by these presents for us, our heirs and successors, do give and grant, unto the said A B, his executors, administrators, and assigns, our especial licence, full power, and sole privilege and authority, that he the said A B, his executors, administrators, and assigns, and every of them by himself and themselves, or by his or their deputy or deputies' servants, or agents, or such others as the said A B, his executors, administrators, or assigns, shall at any time agree with, and no others, and from time to time, and at all times hereafter, during the term of years herein expressed, shall, and lawfully may make, use, exercise, and vend his said invention within our United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, in such a manner as to them may seem meet." To avoid further use of formal expressions, we may state that the letters go on to secure to the grantee and his assigns "the whole profit, benefit, commodity, and advantage, from time to time coming, growing, and accruing, and arising," by reason of the invention; to the end that "they may have and enjoy the full benefit and the sole use and exercise" of the invention. Then follows a prohibition directed to all other persons and bodies corporate, commanding neither directly nor indirectly to make, use, or put in practice the invention or any part of it, nor in any wise counterfeit, imitate, or resemble the same, nor make or cause to be made any addition to or subtraction from the same, whereby to pretend himself or themselves the inventor or inventors, devisor or devisors thereof, without the consent, licence, or agreement of the patentee.

From the foregoing it will be seen that the patentee may either assign or grant a licence to use his invention. It seems

doubtful whether it is necessary that letters patent should be assigned by deed. Mr. Joshua Williams, a very eminent lawyer, says, "A deed is said to be necessary for the valid legal assignment of letters patent; but the author is not aware of any authority for this position; and the general rule appears to be that the assignment of incorporate personal property may be made without deed. Perhaps, however, the necessity of an assignment by deed may be implied from the clause in the letters patent which forbids the use of the invention, and without the consent, licence, or agreement of the inventor, his executors, administrators, or assigns, in writing, under his or their hands and seals, first had and obtained in that behalf." ("Personal Property," 7th edit., p. 223.)

All assignments of letters patent are now required to be registered under the Patent Law Amendment Act, 1852, which provides that a "Register of Proprietors" shall be kept at the office for filing specifications in Chancery. In such register must be entered the assignment, or any share or interest, any licence under letters patent, and the district to which such licence relates, with the name or names of any person having any share or interest in such letters patent or licence, the date of his or their acquiring such letters patent, share, and interest, and any other matter or thing relating to or affecting the proprietorship in such letters patent or licence. Until such entry has been made, the grantee or grantees of the letters patent will be deemed and taken to be the sole and exclusive proprietor or proprietors of such letters patent, and of all the licences thereby given and granted.

It may here be convenient to refer to the divisibility of a patent, and it would seem that there is no legal objection to the assignment of part of a patent. By the Act of 15 & 16 Vict., c. 83, s. 36, it was made lawful for a larger number than twelve persons to have a legal and beneficial interest in letters patent. A question has arisen on this, whether the shares of such persons are shares in the profits only or so many rights of property, and consequently so many rights to sue for an infringement. This important subject was discussed by Chief-Justice Erle, in his judgment in the case of Walton *v.* Lavater. It was contended in that case that a grant under letters patent is a one and individual franchise, and that by the assignment of the moiety the whole of the patent remains in the original patentee, but that the assignee of the moiety takes a licence to use the patent and have an account only; and further, that even when the original patentee has assigned the other moiety, and that has become vested in the assignee of the first moiety, so as to make the two moieties then come together in the assignee, yet that the original franchise legally remains in the original patentee without any beneficial interest at all, but the right remains in him, and that the party in whom both the moieties are vested still remains an imperfect owner. Chief-Justice Erle thought, however, that if such a contention were established, it would be most inconvenient. His lordship considered that the act contemplates the assignment of a patent, and shares of a patent, and that an interest in the moiety of a patent would pass, and that the assignment of the second moiety to the same party would vest the whole of the patent in that party. Further, as to the rights of an assignee of part of a patent, it is now perfectly clear that he may sue alone for an infringement without joining in the action, others having an interest in the patent, but no interest in the particular damages.

In the next place, we may consider what is the position of a licensee. The usual course is that the licensee receives permission to use the patent on payment of certain royalties to the licensor, and a main principle is that he cannot deny the validity of such patent. In a case connected with the manufacture of carpets a licensee had obtained from patentees a set of machines, and subsequently obtained another set of the same kind of machine from another quarter. The patentees claimed royalties on both sets, but the licensee set up a defence that the second set of machines were not identical with those of his licensors. The question of fact as to the identity of the machinery was decided adversely to the licensee, and thereupon, in addition to the principle settled as above stated, a question arose whether the obligation of the licensee not to dispute the right of his licensors extended also to the machines obtained by him from another quarter, which were constructed in violation of the patent right. The Lord Chancellor did not consider that there was any doubt that this should be answered in the affirmative. The fact, however, that a person has been licensee of a patent does not stop him from contesting the validity of the patent after the licence has expired.

It has been mentioned that any number of persons may be joint owners of a patent, and it is material to consider what the position of joint owners is. The subject was considered with reference to Green's patent for lawn mowers and garden rollers. The letters patent had been granted to three persons, and the Lord Chancellor (Cranworth) said, "Where such a grant had been made to two or more as joint inventors, it is dangerous for any court to allow one of the grantees to set up a title against the others founded on mere parol (verbal) evidence, or inference from doubtful conduct. The grantee, who in such a case claims an exclusive right, ought to obtain written evidence on the subject; and if, by omitting to take such precaution, he is put to a loss, he has himself only to blame." "The right conferred," he said, "is a right to exclude all the world other than the grantees from using the invention. But there is no exclusion in the letters patent of any one of the patentees. . . . There is no principle in the absence of a contract which can prevent any person, not prohibited by statute, from using any invention whatever. Is there then any implied contract, where two or more persons jointly obtain letters patent, that no one of them shall use the invention without the consent of the others; or, if he does, that he shall use it for their joint benefit? I can discover no principle for such a doctrine. It would enable one of two patentees either to prevent the use of the invention altogether, or else to compel the other patentee to risk his skill and capital in the use of the invention on the terms of his being accountable for half the profits if profit should be made, without being able to call on his co-patentee for contribution if there should be a loss. This would be to place the parties in a relation to each other which I think no court can assume to have been intended in the absence of an express contract to that effect." Therefore, the principle as to joint owners of a patent is that each should be free to make use of the invention under the letters patent.

In a case which arose in 1869, one of two joint owners assigned his share in a patent, and released the assignee from all actions and suits by himself and his partner. The assignment was entered on the register of proprietors, but Lord Romilly ordered the whole deed to be expunged. Where A and B are patentees, he said, both may use the patent, but B cannot dispose of A's share.

We next proceed to consider the position of a purchaser of a patent. A very nice point arose in a recent cause in the Court of Queen's Bench as to the right of a purchaser to refuse to complete his purchase of a patent, on the ground that the alleged invention was no invention at all. The position of the parties in such a transaction is explained by the Lord Chief-Justice Cockburn. "I quite agree," he said, "that where a man supposes himself to have invented something which may have been the subject of a patent, and another man under the same belief, and himself a seller, buys that invention, such a contract may well be, and the buyer takes his chance of its being a patented invention; and if it turns out that the invention does not prove to be new, then it won't do for the buyer to turn round and say, 'I won't buy, because it is no invention at all.' This is very different from the case of a man selling as an invention to another that which in point of fact existed only in his imagination, and had no result. I cannot help saying that in such a case the maker of such an agreement would not be bound by his bargain. There must be some industry used, some novelty produced, and then the man who buys it must take it such as it is." Then he goes on to notice another condition of things. "I can distinguish the case supposed from the case of an invention which has some foundation and effect, but which does not achieve the whole effect for which it was devised. In the case where there is some invention, but its efficacy is only partial, a contract may take place, and the persons contracting will be bound by their contract."

In an earlier case than that from which we have quoted, it was laid down that in the sale of an invention there is no implied warrant. The statement of the complainant, known to lawyers as the "declaration," set out an agreement which recited that the plaintiff had invented a method for the prevention of boiler explosions, and had obtained a patent for the use of the same in the United Kingdom, and was desirous of taking

out patents in foreign countries, and that the plaintiff "agreed to make over and transfer, and did thereby accordingly make over and transfer, to the defendants one-half of the said foreign patents when the same should be obtained, and one-half of the English patent." The defendant pleaded that the invention was wholly worthless and of no public utility, and was not new as to the public use thereof in England, and that the plaintiff was not the first and true inventor thereof. This plea, the court decided, was no answer to the action, on the ground that in the absence of any allegation of fraud it must be assumed that the plaintiff was an inventor, and there was no warranty, express or implied, either that he was the true and first inventor within the meaning of the statute of James, or that the invention was useful or new, but that the contract was for the sale of the patent such as it was, each party having equal means of ascertaining its value, and each acting on his own judgment.

Of course it is a different matter if there is a want of *bona fides* on the part of the person selling a patent or a right to use it. There is a decided case in which the plaintiff contracted that the defendant should have the exclusive right to sell certain things for which patents had been obtained. The plea there raised the objection that the plaintiff knew at the time of making the contract that the patent was void. The patent being void, no right could be conferred under it, and therefore the defendant had no consideration for the promise to pay which he was alleged to have entered into.

On the subject of contracts by purchasers and licences under patents, it must be taken, therefore, that unless there be fraud or a knowledge on the part of the vendor or licensor that the patent is void, or as a matter of fact the supposed patent does not exist, and no right is conferred, any contract entered into to make certain payments, whether as purchase-money or royalties, will be binding.

We have been dealing with the assignments of patents, and it is necessary shortly to notice that it has been suggested that an assignment of the right before the patent is taken out, enables the assignee to take out the patent. Some doubt, however, hangs about this point, inasmuch as the declaration required by the statute states that the petitioner is the true and first inventor, which would be untrue of a mere assignee. There is no doubt that the courts would be jealous of any abuse of the process provided by the patent law. One instance of such abuse is before us, where a party to whom a discovery had been communicated took out a patent in his own name, though a condition of the communication was that he should not avail himself or take any undue advantage of it.

Inasmuch as a licensee can have no interest beyond the term specified in his licence, he cannot apply for a prolongation of the term for which the letters patent were granted. It is otherwise as concerns assignees, to whom the Privy Council will grant a prolongation, taking care, where there are assignees of a moiety only, and the patentee dies during the application, as occurred in the case of Herbert's patent for mooring buoys and light vessels, to secure the interests of his representative in the other moiety.

In concluding this notice of the rights and privileges of the patentee, we must remark that we have in this paper been dealing with his power to use his letters patent for the purpose of profiting by his invention, and we need hardly say that the payment of royalties on the granting of licences is frequently the largest source of revenue to an inventor, and the only source, short of assignment, where he is not his own manufacturer. But there is a very wide field in which patentees too often find themselves fighting for the protection of their rights, and this leads us up to the question of infringement. The letters patent, as we have already described them, speak of the *exclusive right* to use the invention which is granted to the patentee, and if any one interferes with this right it is an infringement of it. It may be premised that there can be no such thing as an infringement until the patent is taken out, or until provisional protection has been obtained under the provisions of the Patent Law Amendment Act, 1852. Such interference with the rights of a patentee may be restrained by injunction issuing from the Court of Chancery, and damages are recoverable against the person infringing. This is a part of the subject which will require to be dealt with at some length, and we therefore reserve it for our next paper.

TECHNICAL DRAWING.—LXXXII.

DRAWING FOR CABINET-MAKERS.

Fig. 625 is a view of a pedestal writing-table, with drawer and cupboard, the spectator being situated on the right of the object.

In commencing this, draw the entire block as if the drawer were not open, and regardless of the recess. When this general form is believed to be correct, draw the perpendiculars for the inner sides of the pedestal cupboards, the space between these representing the recess. To give to this space the appearance of depth, a line must be drawn to the point of sight from the inner line of the left pedestal, which must be terminated by a horizontal line representing the bottom of the back of the recess; a perpendicular at the intersection of these two lines will give the junction of the side of the cupboard with the back of the recess.

The doors of the two cupboards having been drawn, sketch the exact position of the drawer *as if closed*, for it will at once be understood that the angles of this rectangle will be those which will guide the edges of the drawer.

Therefore, through the two upper angles and from the lower one on the left side draw lines which would converge to the point of sight, since the edges of the drawer are of course parallel to the sides of the table.

Draw a horizontal line joining the two lines proceeding from the two upper points, and this will give the upper plane of the drawer. Draw a perpendicular at each end, the length of which will be guided by the point at which the one on the right side intersects the third line of the drawer. From this point draw a horizontal, completing the front of the drawer, which, it is obvious, will be really larger than the original rectangle; for, since the drawer is supposed to be open, its front is of course nearer the eye than the front of the table, of which when closed it formed a part; and thus, if this study were worked by perspective, the front of the table would be said to be "within the picture," since it could not be in the foreground, because if the plane of the picture were placed in front of the object with the drawer open, the front of the drawer would touch it, whilst the table itself would be at a distance equal to that at which the drawer projects from it.

The edge of the drawer—that is, the thickness of the wood of which it is made—is now to be added, then the divisions. Those known to be parallel to the sides will converge to the point of sight, whilst the others will be parallel to the front.

The rest of the detail, the desk, etc., will not require any special remark. The light is supposed to come from a point in front of the object, and on the left side of it; and therefore the whole of the right side of both table, drawer, and desk are shaded, as is also the right side of the pedestal which forms one of the walls of the recess, whilst the distant wall of the recess is covered with a middle tint. The shadow cast by the drawer falls on the front of the cupboards and into the recess; it becomes broader on the back of the recess, since that surface is farther back. This will be understood from the drawing, as will also the shading, etc., of the minor parts.

A few touches may be added to indicate the grain of the wood, but care must be taken not to overdo this, since absolute or laboured imitation of the graining is unnecessary and out of place.

WOODS USED IN CABINET-MAKING.

The following account of the principal woods used in cabinet-making will be found useful and interesting. The paragraphs marked (*) are quoted by express permission from Messrs. Holtzapffel's excellent descriptive catalogue:—

* *Best Furniture.*—Mahogany, walnut, rosewood, oak, various kinds; maple, satin-wood, Amboyna, black ebony, cherry-tree, Coromandel, sandal-wood, sweet chestnut, sweet cedar, tulip-wood, zebra-wood, camphor-wood.

Common Furniture and Inside Works.—Beech, birch, cedar, cherry-tree, deal, pine.

Even Grain, proper for Carving.—Lime-tree, pear-tree, pine.

MAHOGANY.

Although the mahogany is a native of too warm a climate to allow of its cultivation as a timber-tree in this country, yet it is applied to so many uses, and is so well adapted for most of them, that it has become essentially a "furniture wood," and therefore an extended notice of it is absolutely necessary.

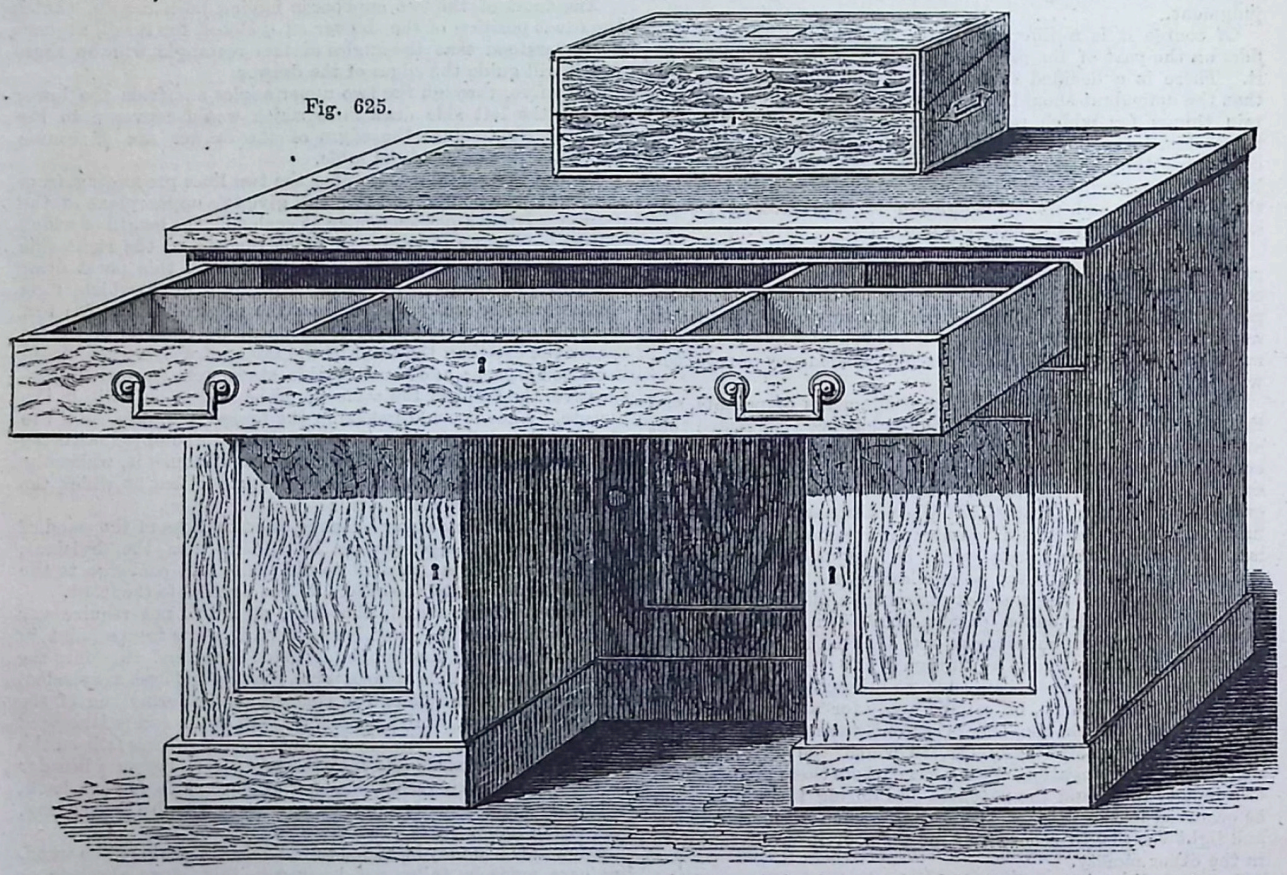
There are three species of mahogany: common mahogany (*Swietenia mahagoni*), *Swietenia febrifuga*, and *Swietenia chloroscylon*, the first being a native of the West India Islands and the central parts of America, and the second and third natives of the East Indies. They all grow to be trees of considerable magnitude, the first and second being among the largest trees known. They all afford excellent timber.

Swietenia mahagoni is perhaps the most majestic of trees, for though some rise to a greater height, this tree, like the oak and cedar, impresses the spectator with the strongest feelings of its firmness and duration. In the rich valleys among the mountains of Cuba, and those that open upon the Bay of Honduras, the mahogany expands to so giant-like a trunk, divides into so many massy arms, and throws the shade of its shining green leaves, spotted with tufts of pearly flowers, over so vast an extent of surface, that it is difficult to imagine a vegetable production combining in such a degree the qualities of elegance and strength, of beauty and sublimity. The precise period of its growth is not accurately known, but the time of its arriving at maturity is probably not less than two hundred years. Some idea of its size, and also of its commercial value, may be formed from the fact that a single log imported at Liverpool, weighing nearly seven tons, was in the first instance sold for £378, was resold for £525, and would, had the dealers been certain of its quality, have been worth £1,000. Mahogany of remarkable fineness is very costly.

As is the case with much other timber, the finest mahogany trees, both for size and quality, are not in the most accessible situations; and as it is always imported in large masses, the transportation of it for any distance overland is so difficult, that the very best trees, both on the islands and on the mainland—those that grow in the rich inland valleys—defy the means of removal possessed by the natives. Masses of from six to eight tons are not very easily moved in any country, and in a mountainous and rocky one, where little attention is paid to mechanical power, to move them is impossible, and thus much of the finest timber remains unemployed.

The discovery of mahogany was accidental, and its introduction into notice was slow. The first mention of it is that it was used in the repair of some of Sir Walter Raleigh's ships, at Trinidad, in 1597. Its finely-variegated tints were admired; but in that age the dream of El Dorado caused matters of more importance to be neglected. The first that was brought to England was about the beginning of last century, a few planks having been sent to Dr. Gibbons, of London, by a brother who was a West India captain. The doctor was erecting a house in King Street, Covent Garden, and gave the wood to the workmen, who rejected it as being too hard. The doctor's cabinet-maker was employed to make a candle-box of it, and as he was sawing up the plank he also complained of the hardness of the timber. But when the candle-box was finished it outshone in beauty all the doctor's other furniture, and became an object of curiosity and exhibition. The wood was then taken into favour. Dr. Gibbons had a bureau made of it, and the Duchess of Buckingham another. The despised mahogany now became a prominent article of luxury, and at the same time raised the fortunes of the cabinet-maker, by whom it had at first been so little regarded.

Fig. 625.



The mahogany-tree is found in great quantities on the low and woody lands, and even upon the rocks in the countries on the western shores of the Caribbean Sea, about Honduras and Campeachy. It is also abundant in the islands of Cuba and Hayti, and it used to be plentiful in Jamaica, where it was of excellent quality; but most of the larger trees have been cut down. It was formerly abundant in the Bahamas, where it grew on the rocks to a great height, and four feet in diameter. In the earliest periods it was much used by the Spaniards in ship-building. When first introduced by them it was very dark and hard, and without much of that beautiful variety of colour which now renders it superior to all other timber for cabinet work; but it was more durable, and took a higher polish with less labour. At that time it was called Madeira wood, though it appears to have come from Hayti and the Bahamas. Of course it was wholly unknown to the ancients. It was first introduced in the sixteenth century, but it was not generally used in England until the eighteenth.

MINING AND QUARRYING.—XXX.

BY GEORGE GLADSTONE, F.C.S.

SILVER (*continued*).

CUPELLATION—REFINING—GERMAN PROCESS—ASSAY OF BULLION—PROPERTIES OF SILVER—ALLOYS—PLATING—SALTS OF SILVER.

THE silver is separated from the enriched lead, or "lead riches" as it is often called, by cupellation. This interesting process has been briefly described in treating of the assay of silver ores, but the arrangements for carrying it on upon a large scale deserve further consideration.

This work is done in a reverberatory furnace of peculiar construction, the cupel forming the hearth, and being removable. Fig. 1 represents a horizontal section just above the cupel or test, and Fig. 2 a vertical one through the centre from side to side. The fire-place, A, is separated from the cupel, B, by a fire-bridge, C, and the waste gases, after having circulated over the surface of the metal, are carried off by the two flues, D D, which afterwards unite in a downward one, E, and pass through it to the chimney.

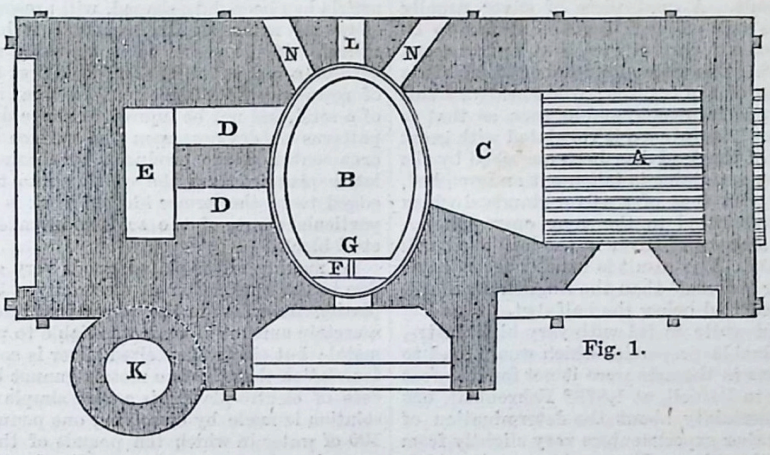


Fig. 1.

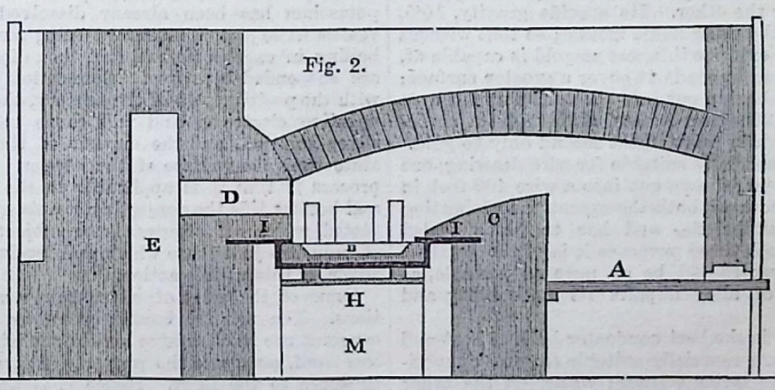


Fig. 2.

The cupel itself is contained in an oval iron ring about 6 inches in depth and 4 feet in its longest diameter; it is strengthened by having four broad straps of iron across the bottom, and riveted to the sides of the ring. To prepare it for use, ground bone-ash, together with 2¼ per cent. of pearl-ash, is worked up with just sufficient water to make it cohere properly; the iron frame is then filled with the composition, and it is beaten down into a solid mass. The centre part is then scooped out with a small trowel, until the bone-ash occupies the form indicated in the drawing, the sole being left 1¼ inch thick, and the sides sloping upwards; in front a portion, F, called the breast, is left of the full height, while in front of that again is a portion which is cleared out altogether: through the breast a little channel, G, called the gate, is made, for drawing off the overflow. A second and third gate is often made at the side of the first during the cupellation, as the original one becomes corroded and no longer serviceable. The cupel must be left for some days to dry before it can be used. When ready it is fixed firmly in its place, by being wedged tightly between the cross-bars, H, below, and the compass ring, I I, above.

The fire is only moderate at first, lest the cupel should crack and exfoliate by being too suddenly heated. When this is thoroughly annealed it is raised to redness, and then the lead riches which have been melted in a separate pot, K, are poured into the cupel. When the temperature of the furnace has risen to the melting-point of litharge, the blast, generally driven by a fan, is let on through the twyer-hole, L. The lead becomes oxidised by this means, and the litharge produced on the surface of the metal is blown forwards by the strength of the blast, and escaping by the gate G, falls through the open space in front into an iron pot, travelling on wheels, which is placed below at M to receive it. The cupel is always kept full; for which purpose pigs of the enriched lead are pushed forward through the pig-holes, N N, as required, which, as they melt, run in and mingle with the rest.

By continuing this process the richness of the alloy which remains upon the cupel will gradually rise; but when it reaches about 3,000 ounces to the ton it is desirable to draw it off, which is done by drilling a hole from below through the bone-ash, and letting the metal flow into another pot placed underneath to receive it. After being tapped the hole is closed up again with a plug of moistened bone-ash, and the operation proceeds as before. If the metal operated upon contained 250 ounces to the ton the tapping will occur about every twenty hours, during which time about 4 tons of lead will have been converted into litharge.

The very rich alloy which is produced by the first cupellation, is then refined a second time by a precisely similar process, and often in the very same furnace which was used on the first occasion. It is found best to make two separate operations of it, as the last part of the process needs careful management; and the litharge which passes off from the cupel will be richer in silver than the previous parcel. Just as the last traces of lead are being oxidised the fire should be urged considerably to remove them as completely as possible, and keep the silver thoroughly melted. After this the fire is withdrawn, and the silver is left to cool gradually. The cake of metal is then taken out of the cupel, any impurity is brushed off, and it may either be sold in that state, or remelted and cast into ingots. The moulds used for this purpose are made of iron, which are oiled and dusted over with charcoal powder before using. The silver thus obtained will only contain about 0·002 to 0·003 per cent. of lead.

The loss of lead during the two refinings will amount to about 5 per cent., but that which has been absorbed by the bone-ash of the cupel is recovered by being resmelted.

In some parts of Germany the whole process of separating silver from lead is done by cupellation; the first operation being performed in a furnace of peculiar construction, and the later ones in an ordinary bone-ash cupel. The former has a large hearth nearly circular in form, with an aperture on the one side for charging it, and another on the opposite side for the litharge to flow out. At the back is a furnace, and near it two twyer-holes for supplying the blast. The furnace communicates by a bridge with the hearth, and where wood is used it has no chimney. The hearth is covered by a sheet-iron hood, suspended to a crane, so that it can be raised and lowered as required. The hearth-bottom is made of brick, and this is overlaid afresh every time with a composition called "kalkmergel," instead of bone-ash. This particular kind of marl, which is found in some localities, contains a large proportion of carbonate of lime, there being about two-thirds of the latter to one-third of clay. Where a marl possessing the proper qualities does not already exist, it

is made by working two or more up together in such proportions as may be required. During the cupellation it becomes permeated with oxide of lead to the depth of 2 or 3 inches; this portion is separated from the rest, and returned to the lead reduction works. The hearth is usually about 10 feet in diameter, and in the Hartz district about 8 tons is the usual charge: the loss of lead during the operation amounts to about 8 per cent., and the "blicksilber" produced contains from 94 to 95 per cent. of fine silver. The blicksilber is again refined in a bone-ash cupel similar in principle to that used for the same purpose in England.

Bullion always contains more or less alloy; the English standard is 11 oz. 2 dwt. of fine silver to the pound, equal to 92½ per cent. The value of it, therefore, can only be ascertained by having it properly assayed. The principle upon which this is conducted is precisely the same as that already described for the assay of silver-lead; but greater precautions are taken to ensure accuracy of result. A small piece of silver, usually about 10 to 15 grains, is cut off each ingot that has to be assayed; these are flattened out, carefully weighed, and wrapped up in pieces of sheet-lead. The requisite number of cupels is then placed in the muffle of the furnace; when heated, a sufficient quantity of lead is put into each, and as soon as that is melted the silver is put in. The furnace is regulated with great care, and when the whole of the lead has been absorbed by the bone-ash, the bead of silver remaining is taken out and weighed, and the result compared with that of a silver standard which has been simultaneously submitted to the same operation. A further allowance for the amount of silver in the lead used, will give the exact determination. The result is usually recorded as so many dwts. "better" or "worse" than the English standard, but the calculation is not carried below the half dwt.

Pure silver is a brilliant white metal with very high lustre, and possessing several valuable properties which would lead to a multitude of applications in the arts were it not for its great cost. It melts, according to Daniell, at 1,873° Fahrenheit, but there is always some uncertainty about the determination of high melting-points, and other experimenters vary slightly from him either on one side or the other. Its specific gravity, 10·5, is low as compared with the other noble metals; so that without being reduced to such an extreme thinness as gold is capable of, a given weight of silver can be made to cover a greater surface; one grain, indeed, can be beaten out into sheets the united area of which will amount to 98 square inches, a test of its malleability which makes it rank in this respect second only to gold.

Its tenacity renders it specially suitable for wire-drawing, one grain being capable of being drawn out into a wire 400 feet in length. But in the progress of both the operations of beating and drawing it becomes brittle, and has to be annealed from time to time. For both these purposes it is of the greatest importance that the silver should be as pure as possible, as the smallest admixture of alloy impairs its malleability and tenacity.

Of all the metals silver is the best conductor both of heat and electricity. It is therefore especially suitable for many experiments connected with the latter science; while, on the other hand, it renders necessary the breaking of the connection, by some good non-conductor of heat, in the handles of tea-pots and coffee-pots made of this metal.

Pure silver does not combine with the oxygen of the atmosphere at any ordinary temperature; but any alloy with copper will, on exposure at a red-heat to the action of the air, turn black on the surface in consequence of the oxidation of the copper contained in it. Sulphur, however, readily acts upon the pure metal, producing a dark-coloured stain, and hence it soon becomes tarnished in London or any other large town, the air of which is always more or less impregnated with sulphurous gases from the coal fires, gas lights, etc.

All the alloys of silver are harder than the metal itself, but few of them are of much utility except that with copper, as this metal does not materially affect its colour, even when the proportion of the latter is considerable. Thus the 7½ per cent. of copper which is added to the pure metal to make standard silver, still leaves a compound of sufficient brilliance and whiteness; and for the purpose of the coinage such an addition is absolutely necessary, as the pure metal is too soft to bear the constant wear and tear of daily circulation. The two metals, however, do not perfectly combine, and the centre of the ingot produced is always found to contain a rather larger proportion than the outside: in minting it the metal is cast into bars of 18 inches long by 1 inch thick, and then rolled out into ribands of the thickness required for the coins which are intended to be struck. In Switzerland an alloy consisting of 90 per cent. of silver and 10 per cent. of nickel is used for coinage; and for various other useful purposes a larger proportion of the inferior metal may be used. A compound containing 13·4 per cent. of nickel is of a greyish-white colour, and takes a high polish, besides which it is highly magnetic.

Beyond the almost universal employment of silver for the purpose of a circulating medium, large quantities of this metal are used for ornamental purposes. The productions of the silversmith are principally the result of hammering, the operations which they have to undergo in this manufacture being very similar to those already described in our paper on "Copper" (Art. XXI.). The surface of the silver, after the vessel or other article has been duly shaped, will present a dull appearance and show the marks of the hammer: it has, therefore, to be burnished. If the vessel to be operated upon is hollow, as in the case of a coffee-pot, the inside is first filled with a composition of rosin and other ingredients, so that it may have the firmness of a solid, and not be injured in shape during the process. Such patterns or devices upon the surface as may be required for ornamentation are produced by chasing and engraving. The latter plan involves the cutting into the metal with a sharp-edged tool; the former kind of work is done by hammering the particular parts of the surface intended to be chased upon a steel block.

In making silver-plated goods very great improvements are due to the application of electricity. Upon the old system of plating described in the paper just referred to, the silver after a certain amount of wear was liable to peel off from the inferior metal; but electro-deposited silver is so intimately united to its foundation that the two metals cannot be separated. The process of electro-plating is a very simple one. A bath of silver solution is made by dissolving one pound of cyanide of silver in 100 of water in which ten pounds of the yellow ferrocyanide of potassium has been already dissolved. In this the copper vessels to be plated, after first being rendered perfectly clean by boiling in caustic potash, and then dipped in acid and washed, are suspended by wires. Connection having thus been made with the positive pole of the battery, the copper will become the negative electrode, and will cause the decomposition of the silver solution, and the deposit of the silver in the metallic state over the surface of the copper. One advantage of this process is that it is applicable to the most intricate pattern; and besides this the projecting points and angles of the objects plated, which will afterwards be subject to the greatest amount of wear, are just those which will receive the thickest deposit of silver by this voltaic action.

Some of the salts of silver have a variety of useful applications. The nitrate, familiarly known as lunar caustic, is of constant use in chemistry and in medicine; and, though colourless itself, possesses the property of turning to a dark colour on exposure to the light. Hence it is the essential ingredient of most of the indelible marking-inks; and has been extensively adopted by photographers. The chloride, iodide, and bromide are also similarly affected by sunlight, and are used for the same purpose.

Another combination of silver possesses properties of a very different character. By treating the oxide with strong ammonia, or a compound of caustic potash and ammonia, a product is obtained which is of a most destructive and dangerous nature. Fulminating silver, even when moist, will explode by percussion; but when perfectly dry the friction caused by the touch of a feather is sufficient for the purpose. It is analogous to the fulminate of mercury, and either preparation will serve the manufacturer of percussion-caps.

In jewellery, silver, though not used to the same extent as gold for this purpose, is frequently selected by the jeweller for the setting of stones which, though extremely beautiful in themselves, do not possess the same intrinsic value as the stones which are commonly known as precious stones. Among these may be mentioned the madrepore, agate and cairngorm. Chains, brooches, shirt-studs, wrist-buttons, and other similar articles, when made to resemble old silver by oxidation, are effective as ornaments for the person.

SANITARY ENGINEERING.—XXVI.

THE DRAINAGE OF VILLAGES AND COUNTRY TOWNS.

In the two papers immediately preceding the present, we have dealt with the detail of metropolitan drainage, giving as much information as the space at our command would allow, and we now take up the question of what may be called village drainage, as contrasted with large metropolitan centres: the conditions are altogether different, and another set of circumstances has to be considered. In large towns an ample water-supply, laid-on and available when required for flushing purposes, is supposed, at all events, to be at command, and the funds at the disposal of the authorities should be sufficient to provide the necessary engineering appliances in proportion to the requirements of the situation and the extent of the population; but when we fall below a certain standard, and have to deal with villages and hamlets, where perhaps the great majority of the inhabitants are poor, outlay becomes a matter of great importance, and the question of economy assumes a far more important aspect in its relation to efficiency than in larger operations; and here let us remark that the most perfect sanitary appliances are comparatively useless without what we may call personal attention. The most important, or one of the most important subjects upon which "education" is required, is that of making the best use of the appliances at command. Next to personal cleanliness nothing, perhaps, would be more conducive to the improvement of the general health of the community than a clear and intelligent understanding of the *rationale* of sanitary matters. The ultimate proof of the benefit of sanitary improvements is clearly and absolutely demonstrated by the actual decrease of the death-rate almost in exact proportion to the adoption of judicious measures in various localities, and in our next paper we shall go into this particular question at greater length, illustrating our position by well-authenticated quotations from Government authorities.

To return, however, to the immediate subject. In very small hamlets in poor districts, perhaps the best system of those alluded to in the course of our series is that of Moule's Earth Closets, described in our paper on this subject in Vol. III., page 341 of The Technical Educator. Its efficiency and salubrity, when properly attended to, are undoubted, and the remanet of the soil is at once available for the garden or the field. No water-supply is required, and the fittings may be of the cheapest description; but personal care and attention are indispensably requisite, or else the evils attendant upon the most inefficient sanitary appliances are the inevitable result.

Advancing somewhat higher in the scale of population, we next come to towns which are small enough to be efficiently drained by pipe-drainage alone, but whose population and extent are not sufficient to require or to warrant the expenditure required for a system of brick-built sewers; and here we are indebted to a series of reports by J. W. Bazalgette, Esq., engineer to the Metropolitan Board, for some of our details. We must, however, first call attention to some points of general importance in connection with the subject. As a rule, pipe-sewers are not adapted to receive the surface drainage from those streets and roads upon which there is a considerable amount of traffic. If there be little or no traffic there will be proportionally little refuse dropped, and comparatively little detritus produced by wear and tear to be washed by rains into the sewers; and if the surface be paved, there will be less road-drift washed into the sewers than there would from macadamised roads. Pipe-sewers are not fitted to receive both house and subsoil drainage, for this reason, that their use in removing the house drainage either to the nearest streams or to a reservoir of deposit for disinfecting purposes, or otherwise, renders it a matter of necessity that their joints should be perfect, and that there should be the minimum of leakage; while the only means by which they can be made available for the latter purpose—viz., subsoil drainage—is by allowing the entrance of water throughout their entire course, by means of joints and other openings, which must manifestly neutralise their first and most important duty, by allowing the escape of the sewage through the surrounding ground. They should also be kept in a satisfactory state, have a considerable amount of water constantly passing through them, and they require, under almost all circumstances, comparatively steep falls, and to be very carefully laid. Where all these conditions can be complied with, the use of pipe-sewers only is undoubtedly advantageous. The size that should be used is the next question; and here let us clearly express our opinion that the most important point is to have them large enough, as a small pipe frequently gets stopped at a certain point, and as there is nothing above the surface to indicate it, the pressure of the water opens the adjoining joints, and the sewage passes into the surrounding soil, where, if circumstances allow of its easy escape, the defect may continue for many months before it is discovered. There may be many causes of obstruction—indeed, they are as various as possible. Extraneous substances causing gradual accumulation; external accident, the breaking of the pipe, the disturbance of adjoining ground for building or otherwise, the settlement consequent upon a new building, or even a trifling variation of the level of the pipe itself, may be mentioned as some of the most frequent. This, however, should always be borne in mind, that an error of level or a settlement amounting to three inches would entirely choke a pipe of that diameter, which, however, we consider, in the first place, too small for general adoption, although such have been used. It would half-fill a 6-inch pipe, and materially interfere with its efficiency, while in the case of a 12-inch pipe it would merely form a sort of bottom deposit of a quarter the depth of the pipe, and occupying a comparatively small section of its area.

We now abstract from Mr. Bazalgette's report some particulars of the drainage of the town of Rugby. The population is about 8,000, and there are about 1,100 houses. The house drainage was provided for by pipe-sewers, and water-works were carried out at the same time, the whole being finished in the year 1852. The public sewers are laid at an average depth of eight feet, and vary from six to twenty-two inches in diameter; the private sewers and drains, from four to six inches. The inclinations or falls are remarkably favourable, 1 in 50 or 1 in 60. The cost of the public sewers has been about £5,000. The water is laid on on the constant supply system, and the outlay for water-works has been £10,000; the water-pipes being laid about sixteen inches below the surface. The private works, in addition to the public sewers, cost about £8,800. The rateable value of the property included in the drainage area is about £28,600. A special rate of 10d. in the pound was levied to pay off the cost of public works, and for the supply of water 4d. in the pound is charged to all consumers, also 2s. 6d. per annum for each horse, and 1s. 6d. for every cow.

Sandgate is the next town to which the report refers. It is described as a remarkably healthy and pretty village, about a mile and a half west of Folkestone. It stands mainly upon a single line of road, parallel with and close to the seashore, at the foot of a range of hills, which rise precipitously from the sea, and prevent the extension of the line of houses except along the line of the shore. The beach, as well as the subsoil of the village, consists of shingle, the place containing, at the date of the report, 330 houses, and a population of about 1,400, considerably increased during the summer months by the visitors for sea-bathing, upon whom the population is mainly dependent for support. From its position resting upon a sea-beach shingle, it required comparatively little drainage, nature providing the most perfect subsoil drainage, as may be well imagined from the preceding description of the site.

The public sewers and water-supply were carried out under the General Board of Health, by their inspector, Mr. Rammell. No considerable extension of the village was contemplated or provided for in the general scheme. The sizes of the public sewers vary from six to twelve inches in diameter, and their inclinations from 1 in 6 to 1 in 320. The pipes are of stone ware with sockets, from London, and the joints are made with clay. The arrangement is peculiar, and would probably not be repeated at the present day; but as our object is not to start theories, but to give records of work actually carried out and in operation, we quote from the report:—

"The public sewers consist of four lengths of pipes, forming one line, under the north side of the main street. These lengths are severally of six inches diameter at the upper end, and increase to nine inches. They are arranged in two pairs, the lengths of each pair fall from opposite directions and meet at a certain point, from whence they discharge, through a common outlet at right angles with them, into the sea."

A reference to the peculiar situation of the place, described above, will render this description intelligible. These lengths measure 583, 320, 203, and 330 yards. The first portion of the outlet for the first two lengths is a 12-inch stoneware pipe, 73 yards in length; total, 1,509 yards stoneware pipe. The first two lengths discharge through a 12-inch pipe into a large egg-shaped brick reservoir, 7 feet 6 inches by 5 feet, and 60 feet long. The reservoir is below high water, and stores the sewage for about three hours per day. (For a detailed explanation of the *rationale* of this arrangement we must refer to some of our previous papers on this subject.) It is furnished with a flap and iron discharge-pipe to low water.

This describes the lowest section of the Sandgate sewage. We have before us the particulars of the other sections, but refrain from giving them, as they involve no practical detail or general principle which has not already been completely described in the course of these papers.

Now for the question of comparative outlay. In this we must include the water-works. There are two reservoirs: the western one 83 feet above Ordnance level, and the eastern one 67 feet. They are each capable of holding about 20,000 gallons, and the supply is derived from natural sources in the surrounding soil. The system is supposed to be that of constant supply. For details we must refer to previous papers; but when water runs short, as in the dry season, the water is turned off at night. About 25,000 gallons per diem pass through the sewers. The outlay may be taken as under:—

	£
Water-supply (about)	2,500
Public sewage	1,000
Private works and incidental expenses .	2,500
	£6,000

The rateable property in the drainage area is, say, £4,000; the water-rate is 1s. in the pound; the sewers' rate 6d. in the pound; and the general charges for supervision, etc., are paid out of the district rate, say 1s. in the pound; but this also includes a lighting rate of 6d. The report gives full detailed prices of the various items and materials used, but these our space compels us to omit.

The report next embodies some smaller particulars of Tottenham, but as they present no distinctive features, we omit them altogether.

One more example, and we conclude. We select the district of St. Thomas, Exeter. The population is about 6,000, and the total number of houses 678. The subsoil, to the depth of which the sewers are laid, is clean river gravel and shingle, showing that the lower portions of the district were at one time under water and subject to tidal influence. The public sewers were executed by Messrs. Dymond and Son, and consist of stoneware socket pipes of London manufacture, varying in diameter from four to eighteen inches, and in inclination from 1 in 22 to 1 in 1,000. The 18-inch and 15-inch pipes are almost entirely outside the town, and they are flushed frequently from places constructed for that purpose. The actual cost of the works, as quoted by Messrs. Dymond in a letter to Lord Palmerston, was £2,371. To this the private works have to be added, which may be assumed at such a sum as would raise the total outlay to £6,000. The rateable property and the sum raised annually for repayment of outlay, etc., we might quote; but having already given several examples of the working of the system, it is unnecessary to say anything more on this point.

Our object in this paper has been to show the practical working of the application of pipe-drainage, pure and simple, to villages and towns of limited population, giving a few financial data as to outlay and rates, and in every instance we have quoted the works have actually been carried out, and we are dealing with facts and not opinions. We should wish this paper to be read in connection with our previous papers on house drainage and the ventilation of house drains, as the one subject is in direct relation to the other, and had we space at command we might elaborate the application of our previous technical detail to the general arrangements described in the present article. We cannot, of course, attempt to give a history of the extensive sanitary works that have been in progress in various localities throughout the country within the last few years: our selection must be regarded as simply illustrative.

In our next paper we intend to give a few statistics as to the effect of sanitary improvements in diminishing the death-rate of the population, thereby reducing to a demonstrative certainty their advantageous effect; and the succeeding and last paper of the series will be devoted to a summary of previous articles, setting forth a comprehensive view of the general scheme upon which the series has been written, and enabling the reader in quest of special information to refer at once to that particular section of the subject in which he may happen to be most interested.

MAP AND PLAN DRAWING.—VI.

By C. C. King.

BOX SEXTANT—SKETCHING WITHOUT INSTRUMENTS—PLANE TABLE—CONVENTIONAL SIGNS—COLOURS USED—UTILISATION OF EXISTING MAPS—COPYING MAPS.

The "Box" Sextant.—Another equally portable instrument, and one of very great utility in rapid surveys, is the "pocket" or "box" sextant. The principle of its construction is identical with that of the larger instrument described in previous pages, that is to say, a movable arm, holding a mirror perpendicular to its surface, moves over a graduated arc, and reflects one of the two objects between which an angle has to be observed on to a fixed mirror or horizon-glass of which only the lower half is silvered. The main difference is, that the arc and arm are on the surface of a small cylindrical box, the cover of which can be screwed on to the bottom, and thus form a support for holding it in one hand. It is provided with a telescope, which is, however, rarely used except for adjustment, and reads by means of a vernier to one minute of an angular degree. Latitude can be determined by a meridian altitude, longitude by means of a lunar observation, and the heights of buildings or hills by observing angles of elevation and measuring a base, or a portion of it. Thus, if the point B (Fig. 20) be accessible, the angle B A C and the base A B being known, the formula B C ÷ A B = tan. A will give the height of B C.

Again, if it be required to ascertain the height of hill, C (Fig. 21), the angles B A C and B D C are observed, and these with the base, A D, will enable one to find, trigonometrically, the length of B C. The principal objection to the instrument is that the angles taken with it, in the triangulation for example, are not, as would be the case with the theodolite or compass, horizontal angles; but in rough surveying work this is of no material importance, and with a little care in measuring the angles to points vertically beneath the elevated ones, instead of those points themselves, very accurate results may be obtained.

The method of proceeding with the survey is the same as with either the theodolite or compass in its main features, only, as before remarked, the sets of angles are not taken with reference to a meridian, and hence the work is not so rapidly transferred to paper as in the case we have previously examined.

The plane table was an instrument formerly much used by surveyors for the completion of the details of a survey, the points of which had been already determined by other instruments; but as the principle involved is precisely similar to that we are about to describe, it will be unnecessary to make particular reference to it.

Sketching without Instruments.—It frequently happens that a sketch has to be made when no instruments are obtainable, but by means of a single sheet of paper, a pencil, and a straight-edged ruler or piece of wood, such as could always be procured, very valuable work can be produced. In sketching without instruments care is more than ever essential, and it must be always remembered that the principle on which surveying is based is invariably the same whether instruments are employed or not.

As before, therefore, the base is first determined on, and measured by pacing or otherwise; and the extremities indicated by pickets or sticks marked by attaching to them a piece of paper, or even a tuft of grass, so as to render them distinguishable at a distance. The observer then draws a line of any convenient length on his paper to represent the base according to the chosen scale, and placing the paper on the ground with one end of this line immediately over either extremity of the base he has measured, he moves the paper carefully until the base-line he has drawn exactly coincides with the direction of the measured base, the eye being kept as close to the paper as

Fig. 21.

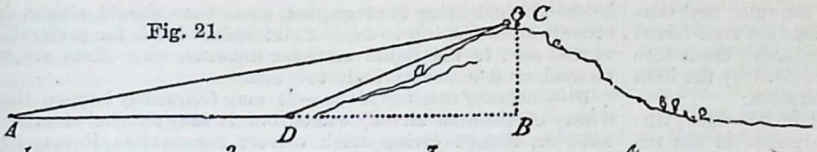


Fig. 22.

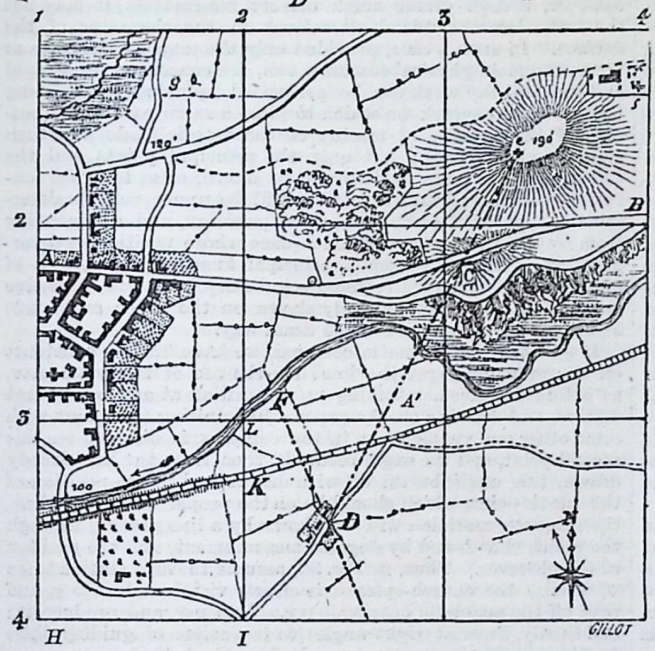


Fig. 23.

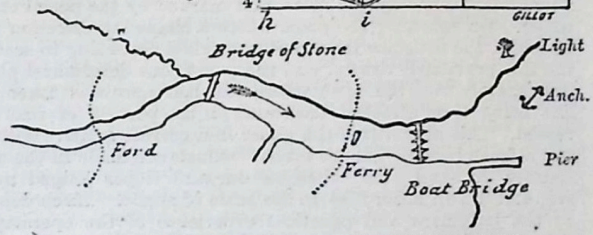
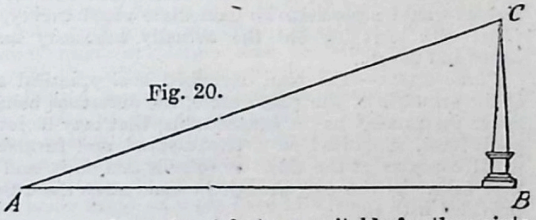


Fig. 24.—CONVENTIONAL SIGNS FOR RIVERS, ETC.

Fig. 20.



possible, and the straight edge of the ruler being used to guide the alignment. Without disturbing the paper, when so placed, he places the edge of the ruler close to the point representing the end of the base at which he is stationed, and aligns the edge again with a series of prominent features suitable for the points of the principal triangulation; and in each case, as soon as the edge of the ruler, while touching the end of the base, has its prolongation in the exact direction of the station observed, a

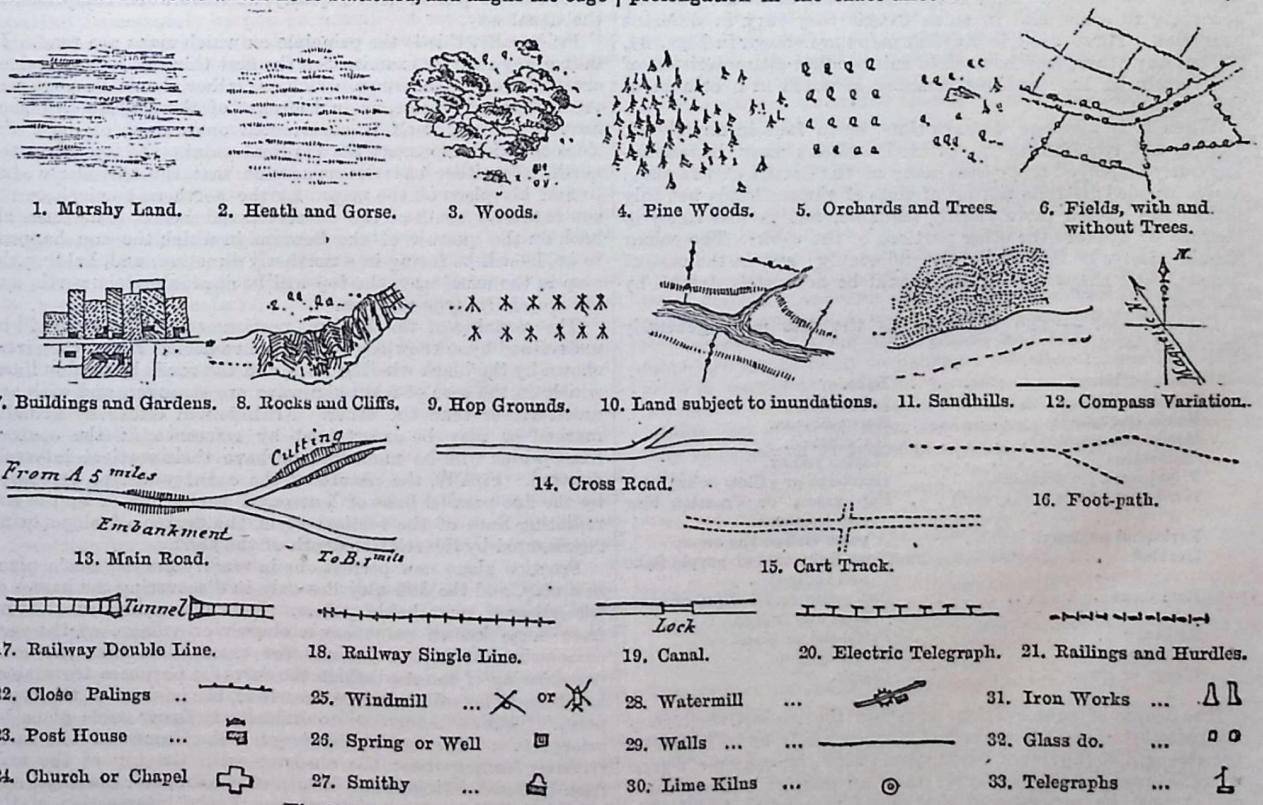


Fig 25.—CONVENTIONAL SIGNS USED IN MAP AND PLAN DRAWING.

line is drawn on the paper along the edge of the ruler, and thus the relative bearings of these different positions are transferred to paper. As in the previous case we have examined, the nature or names of the points whose bearings are decided by the lines should be noted down on them to prevent confusion.

Proceeding, then, to the other extremity of the base, the process is repeated, and thus, as before, the points of the triangulation are ascertained by the intersection of their respective bearings. Traversing is performed in the same way, that is, a known starting-point is chosen, and the paper fixed in its proper position by joining this point with any other one on the sketch, which is in reality visible from it, and, by means of the ruler, directing the line thus drawn on the point selected. The direction of the first straight portion of the traversed road can now be laid down by the ruler, and marked by the pencil on the paper. On reaching the place where a change of direction is to be made, the distance traversed is marked according to scale on the line previously drawn, and the point thus determined placed immediately over the spot where the last pace was taken, the line being then directed backward on the portion of road traversed. This again fixes the paper in a correct relative position, and a fresh bearing can be taken. Offsets are made in the usual manner, hill-tops, etc., sketched in, and slopes judged by the eye, and drawn according to the scale of shade. Much depends on the judgment and practical experience of the operator, as though it is possible he may have a clinometer, or may have even constructed one, it is more likely that he will, in such a case as would necessitate an immediate rapid survey, be unprovided with anything but the actually necessary materials of paper and pencil.

Plane Table.—The plan described is a practical adaptation of the principle of the plane table, the difference being that the latter instrument has a square table, that may be levelled by a spirit-level, supported on a tripod-stand, and furnished with a small compass at the side. A ruler is laid on it, and the bearings taken by the eye, though in some cases the ruler itself is provided with sights.

Conventional Signs.—For convenience' sake, and also to facilitate both rapidity of reading and uniformity of appearance in sketches, a series of conventional signs are used to delineate the details of the sketch. They should be drawn, as far as possible, according to scale, and to some extent they vary in different countries. Those used in English maps are shown in Figs. 24, 25, but any others may be used to suit peculiar characteristics of the terrain, as long as their meaning is noted in a column of reference.

When it is necessary to save time, or in fact in any sketch that is not required to be printed, colours may be advantageously employed to express many of the details of the plan; and in wooded districts the use of tints of various kinds not only makes the sketch more readily readable, but is less likely to confuse or obscure the other portions of the work. The colour should always be laid on lightly and evenly; and in the case of forests, their shape and extent should be accurately defined by the wash.

Colours used.—The following is the list most generally employed:—

Brick buildings	Lake.
Wooden ditto	Indian ink.
Roads (metalled)	Burnt Sienna.
Roads (unmetalled)	Uncoloured.
Cultivation	Naples yellow.
Wood-work (in section)	Gamboge or yellow ochre.
Hard-wood trees (oaks, etc.)	Sap green, or Prussian blue and gamboge.
Park-land or downs	A paler tint of the same.
Heather	Very light tint of purple (lake and indigo).
Pine trees	Sap green and indigo, or gamboge and indigo.
Railways	Brick-red or black.
Telegraphs	Bright yellow.
Water or rivers	Cobalt.

The degree of preservation, or rather the respective value of the metalled roads for transport purposes may be indicated by the strength of the tint of burnt sienna used: for example, a good turnpike road would be darker than an inferior country road, and it must be remembered that when the sketch is inked-in before the colouring is attempted, some time should elapse, in order to allow the ink to dry. Solid Indian ink is far preferable to that sold in the liquid state for drawing, when tints are to be used, as it is not so likely to "run."

Utilisation of existing Maps.—It may frequently happen that a map of the area already exists, but it may not be of recent date, or, though giving much correct information, it may not show the latest artificial alterations in the character of the surface. In such a case, provided only the map be accurate as far as the main physical features, etc., are concerned, very rapid and trustworthy work can be performed by using the existing map as a framework on which to place a more careful delineation of the details. A tracing of the map is made, and then transferred to paper; but only the principal points and the direction of the main roads would be shown, so as to avoid confusion. If the sextant be used it will be unnecessary to determine the position of the magnetic meridian, and commencing from any known point, or from a place whose position is determined by a traverse from a principal known feature, sets of angles will be taken with reference to lines joining the successive stations with the points already shown on the paper, and roads or hedges then traversed in the usual way.

If we have the prismatic compass, we have first to construct on our prepared paper the lines for the use of the protractor, as before described. Taking up a position at any convenient station, and drawing on the paper a line uniting this point with some other one visible from it, the compass is directed on this second point, and the angle read. If, then, from the line already drawn, this angle be set off with due regard to the position of the north point, which should be on the proper side of the line, the magnetic meridian will be shown by a line passing through the point, thus found by angular measurement, and the position of the observer. Thus, in Fig. 22, assume the first station to be D, whence the church-spire, *c*, is clearly visible. Join D *c*, and read off the magnetic bearing, *c* D F. Join D F, and produce it; and finally, draw at right angles to it a series of guiding lines for the use of the protractor. It is evident that we can now find our place readily by interpolation at any point, and as we have already copied the main features, the minor details, such as the character of the slopes, the hill-crests, or water-shed lines, can be put in with rapidity, and the work completed in the usual way.

Practically, this is the principle on which maps are read. In taking any map for examination the first thing to be ascertained are the compass bearings, which are either shown in some convenient corner, or else, as in the case of the English Ordnance Survey, the map itself is constructed on a sheet of paper the sides of which represent the cardinal points, the top being the north. In either case let us assume that the traveller wishes to find his place on the map. In the northern hemisphere the sun is always south of the observer, and hence, if he turns his back on the quarter of the heavens in which the sun happens to be, he will be facing in a northerly direction, and, holding the map in the usual way, the top will be approximately north, and the map in its true position.

The meaning of the different portions of the drawing will be understood by a knowledge of the conventional signs, the rivers shown by the black winding lines, and the roads by double lines, which in the case of main highways are stronger, and with one much darker than the other. Altitude will either be actually marked or may be ascertained by reference to the contour lines, which will be numbered or have their vertical intervals denoted. Finally, the nature of the country will be expressed by the fine parallel lines of horizontal hachuring, or by the fine radiating lines of the vertical style, the degree of slope being represented by the relative depth of the shade.

Practice alone can perfect one in readily finding one's place in a map, and the difficulty lies only in discovering the names of the adjacent remarkable points. It is convenient in starting from some known point, say a church or village, at the very commencement of the journey for example, to take the compass-bearing of the road which the surveyor purposes traversing, and then to lay off, as before described, the position of the north point. There will then be no difficulty in fixing one's place by interpolation, for finding by inquiry the names of the most striking features near the observer, with the top of the map from him and facing north, he can ascertain their bearings, and lay them off from the points observed, the intersection of the

lines giving his place. If no instruments are obtainable, it must be left more to his judgment, and he must endeavour to trace the road he has already come from his starting-point, and by calculating roughly his rate of progress, his place will be approximately found. If, then, some one or two remarkable features near be noticed, and a guess be made at their distance from him at that moment, he can, by means of the map, ascertain what points there are on it of a character similar to those he sees before him; and by placing the top of his map to the north, and then turning it till the actual feature, say a church-spire, and the point marked on the map of a similar nature, lie in the same direction, he will be able to fix his place by the intersection of the line of road he has already passed over, and that representing roughly the bearing of the feature.

Thus proceeding from A (Fig. 22) along the road A B for about 3 miles, the traveller has reached a hill, c, and wishes to find his place. Turning his back on the sun, and holding the map with the top from him, he measures off 8 miles by scale from the point A on the map along the road to *c*. A church is marked at *e* and *f*, and a landmark at *g*, the former being distant about 2 and 6 miles respectively. On examining the country, two spires lie to his right front and a landmark to his left. Arranging, therefore, his map until these lie approximately in the same relative direction right and left, the intersection of their imaginary bearings at *c* will give the traveller's place. This is merely a matter of practice, and a skilled eye can find the requisite information very readily.

Copying Maps.—Maps or plans may be copied in various ways, depending on the requirements of the case. Where great accuracy is necessary the distance may be actually measured by compass or scale, and transferred to the copy, the principal points of the triangulation being first marked, and then the roads and hill-features in the usual order of work. But if rapidity of copying is desired, a tracing may be made by means of the ordinary tracing paper, of all the details, and this transferred to the new sheet by the employment of "transfer" paper. This is simply thin paper coated with black-lead, which is transposed, the coloured side downwards, between the tracing and the plain paper, and the lines on the former being carefully followed by a pointed pencil or piece of wood, an exact copy is made, the lines of which are easily erased, and must hence be marked immediately by pen or pencil. A copy may always be made if the papers are both thin by placing them against the window or a pane of glass fitted in an inclined frame, which renders the operation of copying less laborious than against a vertical surface; but in both the above cases great care is necessary to prevent the paper moving, and errors may also frequently occur unless the eye be kept perpendicularly over the sheet. The papers should be securely fastened together by needles, or prevented from moving by weights imposed on them.

When the paper is so thick as not to be transparent, the copy may be made by placing the original over the fair sheet, and pricking through all the salient and remarkable points with a needle held vertically, the details being afterwards filled in by measurement or hand. This necessarily destroys the value of the original map to a very great extent, and is not advisable for very carefully finished drawings. A better plan is to divide the original map into a series of squares or rectangles of any convenient dimensions, but the smaller they are the greater will be the accuracy of detail. A similar series is drawn on the paper on which the copy is to be made, and any point on the map through which two intersecting lines pass is selected for a starting-point, and the same place marked for the beginning of the work in the copy. Thus, in Fig. 22, A and A′ are the points referred to; and to enable the draughtsman to find the portion he is copying at any moment readily, the vertical and horizontal lines in both plans are numbered.

In reducing maps the same method may be adopted, but in this case the size of the squares on the copy must be in the same proportion as the scale of reduction required. Thus, if it be required to reduce it to one-half, the square for the copy will have sides of half the length of the original; if a plan is required to be enlarged to twice its former scale, the square will be four times the size, and so on. The details are then finished-in by hand, or the distances where lines, roads, etc., cut the sides of the rectangles measured from the nearest right angle are either transferred immediately to the copy, or, if a reduction is to be made, the lengths are divided on a scale into one-half or twice the true dimensions, as the case may be. In Fig. 23 the plan is reduced one-half, and the distances *h i*, *i k*, *k l*, etc., are respectively one-half the length of H I, I K, K L, etc. The sector may be conveniently used for this reduction in the following manner. Open the instrument until the distance between 10 and 10 on the "line of lines" (marked L) is equal to the length of the dimensions taken off the original map; then the space measured by a pair of compasses between 5 and 5 on the same sectoral scale will give the required reduction to one-half of the first measurement.

Proportional compasses may be advantageously used for the same purpose. They consist of two bars with compass-points at each end, the centre of each bar being slotted to admit of the free movement when loosened of a small sliding-bar with a clamping-screw, which further serves as the point on which the arms move. The principle of the instrument is simply that of similar triangles, and by altering the position of the slide in the slot the arms may be so adjusted that the distance between the points at one extremity bears a certain proportion to the space between those at the other end. This proportion is ascertained by means of a scale marked on either side of the slot on the flat surface of the bar, and in adjusting the instrument the two legs are placed carefully covering one another, the screw unclamped, the fine lines marked on the slider adjusted with regard to some proportional mark on the scale, and the screw again clamped.

A more complicated instrument, and one requiring more care in manipulation, is the pantograph, but it is a question whether a really accurate copy can be made by it, though a reduction can be made with very great rapidity. It consists of four brass rulers, two of which are larger than the other pair, forming a rhombus with two adjacent sides produced. The angles of the figure are jointed so as to admit of free movement, and one of the shorter sides, as well as the adjacent longer one, are graduated and marked $\frac{1}{2}$, $\frac{1}{3}$, etc., and have each a sliding index which can be fixed by a clamping-screw, and which has, moreover, a hollow tube either for receiving a pencil or for the purpose of being fitted on a pin fixed in a heavy circular weight called the fulcrum. The angles and extremities of the rulers move freely on small castors, and in the long arm which is *not* graduated is placed a tracing-point with which the two clamping-screws on the other arms of the instrument are aligned.

Thus the pantograph has free movement in every direction about a fixed point, and in cases of reduction this is furnished by placing the weighted fulcrum in the socket of the clamping-screw of the long graduated arm. If now the original plan be placed under the tracing-point in the other long arm, and a pencil be placed in the socket of the clamping-screw attached to the short graduated arm, all movements made by the tracer over the map to be copied will be faithfully repeated by the pencil on a sheet of paper placed below it.

In all cases of copying or drawing maps extreme care is necessary in the mere use of the instruments. Errors multiply so rapidly, and are so difficult to trace, that too much attention cannot be paid to fixing the positions of the main points of the triangulation. An error of a pencil line at this portion of the work may produce a very marked deviation from the true measurement at some other point; and still more in copying maps are errors likely to increase. Facility in taking observations is merely a matter of practice, and it would be almost impossible to give directions that would enable a beginner to acquire the power of using instruments successfully. Skill is only to be gained by actual practice in the field.

FISH CULTURE.—XII.

By Greville Fennell.

NATURAL ENGLISH BEDS—RESTRICTIONS ON DREDGING—TILES AS COLLECTORS—PARCS AT ARCACHON—WEEDS—FASCINES AND WOOD COLLECTORS—SPAT—TERMS AND PRICES IN LONDON MARKETS.

The diminution in oyster production which has taken place in England is not so great as in France; still it has been very considerable. Great natural beds exist, or have existed, in the estuaries of the Thames, Medway, Blackwater, the rivers of Essex and Suffolk, in the Solent, in Langston and Chichester harbours, Milford, Tenby, and other places. The same causes as

exist in France may be assigned for the falling off of the supply. Besides the public beds before named, a very large number of oysters are obtained annually from private grounds in the Thames, the Blackwater, the rivers in Essex, and from the rivers in Suffolk, from the Isle of Wight, from Cornwall and elsewhere. These fisheries are held either by corporations, as at Colchester and Ipswich, or by private persons and companies, as lessees or otherwise. Such private oyster-beds are almost invariably well cultivated, very considerable trouble and expense being bestowed on them by the proprietors, whose efforts are mainly directed to keeping the bottom of the river free from slush and weeds, and destroying the enemies of the oyster—as the star-fish, the dog-whelk (*Purpura lapillus*), crabs, and rough whelk (*Murex erinaceus*), etc. The star-fish encloses the oyster in its grasp, and breaking off the edge of the shell, contrives to devour the fish, whilst the whelks bore through the shell, and, it is supposed, abstract some fluid portion of the oyster, leaving the more solid parts to be eaten by the crabs, which follow in the wake of the whelk.

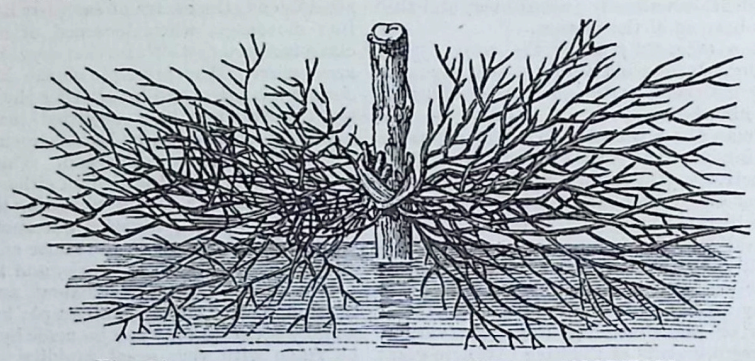


Fig. 26.—MODE OF USING FURZE BUSHES AS COLLECTORS.

Many attempts have been made to increase the means of breeding and fattening oysters by artificial culture. Amongst these may be named Southend, in Essex, in the Roach, Hayling Island, on the Hampshire coast, Herne Bay, Brading, in the Isle of Wight, and the Reculvers and Lymington; but we are not aware how far the foregoing undertakings have been commercial successes. The ponds of Mr. George Tomline, at Nacton, on the Orwell, gave a spat in 1867 and 1869, but not in 1868. The Medina Oyster Fisheries Company at Cowes and Newtown—twenty-four acres in extent—have obtained a considerable amount of spat; but how far their breeding operations have answered their purpose we are not in a position to determine. Nearly all these ponds are similar, the chief differences being in size, and in the kind of collectors used, some consisting of tiles, others twigs, or fascines, slates, stones, and shells, attached by tar or cement to boards, the depth of water varying from two to ten feet. The falling-off in Jersey and the seas about the Channel Islands is directly attributed to over dredging, 400 vessels having declined to three or four. In Scotland, where the most important beds in the Forth and Lough Ryan belong to private persons, and a close season and regulations are observed, accounts appear most favourable; while on the contrary, when some equally important beds were discovered at Wigton Bay, no restrictions being imposed, the oysters were soon dredged out, and may be said to be almost extinct there.

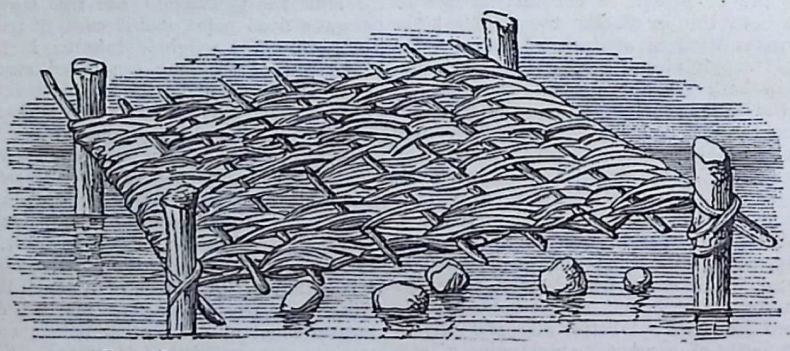


Fig. 27.—MODE OF USING WATTLED HURDLE AS COLLECTOR.

In Wales, at Milford Haven and Tenby, restrictions as to dredging and the size of oysters were once rigidly imposed, and all went well; but an increase of dredging has been permitted, and has greatly diminished the quantity on the beds. At Milford there were only 21 boats dredging twenty years ago: they frequently took 2,000 oysters in a day; now there are 200 boats, the take in the day does not exceed from 100 to 200. These instances go far to prove the wisdom of maintaining some regulations for the repression of indiscriminate dredging. At Arklow and Wexford, in Ireland, the beds have shown an annual improvement from a low state after over-dredging, the change being consequent upon the adoption of a close time, at the request of the fishermen themselves. Still cases are not absent even in Ireland, where positive injury had arisen from want of sufficient dredging, as in the estuary of the Shannon, near Scattery Island, and at Clew Bay, large accumulations of weeds and dirt having arisen. It is lamentable to read that out of 100 grants or licenses, comprising in the aggregate nearly 17,000 acres of some of the most desirable oyster-ground in Ireland, all have, as a whole, fallen very short of realising the expectations of those who promoted legislation on the subject. Hardly one of them has proved a commercial success, whilst most of them must be regarded as total failures, so far as the production of oysters—the greatest object of all—is concerned. In many cases the oysters laid down have fattened, and the grants have thus proved advantageous to the grantee; but this is a small object in comparison with the main object—increased production. The Commissioners attribute these failures almost entirely from not adopting adequate means to promote breeding, though there may be other causes yet to be discovered. The grantees, on the contrary, have satisfied themselves by reaping the benefit of the oysters already on the ground, and the fattening of those placed there. The Legislature never contemplated such a monopoly of the shore or sea-bottom for such purpose; and where the undertaking upon such exclusive privileges were given is not fulfilled, it should be withdrawn. Yet, "diminished as the supply of oysters is in Ireland, and suffering as this branch of fisheries is from exhaustion, there can be no doubt that the banks, both as regards stock and other conditions, are for the most part in a more satisfactory condition than those of the other portions of the kingdom, or of France." And this comparatively favourable state is unquestionably due to the salutary regulations framed and enforced by the Board of Works, whilst the fisheries were under that department, the observance of close time, and the efficient service rendered by the coast guard in carrying out these regulations.

From what has been written, it is not at all intended to prejudice the cultivation of oysters, when properly conducted. On the contrary, the cultivation of crassals (mud-lands) and ebb-dry foreshores is available for either associated bodies of fishermen or individuals. Indeed, it is especially adapted to the wants of a poor population, on a rocky coast, partly fishermen and partly farmers, such as we find in many parts of Ireland, and where the shores are suitable and the requisite materials abound on every side, only requiring labour to make them available. Oysters are not, as yet, so far destroyed at most of these places but they are obtainable by dredging; and if laid in the months of April and May would probably deposit a valuable spat in the parc cleared and prepared for them. From July to the following May no care or attention is necessary.

In the case, however, of estuaries of rivers, bays, harbours, or loughs, when the ground consists of mud-banks or weed-beds,

the process is somewhat different. There parcs may still be made, but it becomes necessary to attend more to the cleansing of the collectors. The collectors may be large flat stones or tiles; but tiles, as employed on the French plan, are easier to attend to, and easier to clean. The following illustrations will show the *modus operandi*:—

At Arcachon the parcs are made upon this plan, and answer admirably. A weed-bed is chosen, a considerable part of which is dry at low spring-tides. Upon this stacks of tiles, laid cross-wise, one tier above another, until they reach some three or four feet in height, are erected and secured by stakes from injury by the run of the tide. About these the weed is hoed closely down, and the oysters are laid. When the spat rises, it drifts under the tiles, and the under side being almost always clear, more or less spat adheres to it. If the top side of the tile is sufficiently clean, much spat wil adhere to that also. Hundreds of tiles may be seen completely crusted over with oysters, as many as two or three hundred being fixed on one tile, so that hardly a portion of the tile is visible. These stacks of tiles are erected about every twenty yards or so, the tops of the stacks being often protected by a thick planking, which is pitched on the under side, and is thickly strewn with shells of mussels, cockles, etc., which adhere to the pitch and receive a share of the spat. This covering aids to protect the young oyster from the effects of the sun during the two or three hours daily that they are exposed at low spring-tides. Fascines, or fagots or hurdles, are also used to arrest the spat, being pegged down in their places, and so secured from floating away; but these do not answer so well in open water as the tiles or stones. In foreshore cultivation shells are also scattered about near the oysters to receive a share of the spat, but these should not be cast down until immediately before the spatting season. One great cause why collectors do not answer at times is that they are often put down too long before the oysters begin to spat, and thus the tiles and shells, etc., become foul, the wood gets greasy or slimy, and the oysters will not adhere to it. Another reason for a defective spat often arises from the fact of the oysters being laid down too short a period before the spatting season. The removal of oysters from one ground and depth of water, just before the spatting season, to another, is often found to be prejudicial. The shorter time which elapses between the laying of the oysters and the spatting the better. Oysters laid on muddy ground often sink into the mud. So long as this happens gradually, the oyster does not suffer, for it contrives, by the flow of the water which it takes in and ejects, to keep a breathing-hole open; but when this occurs from a sudden storm, so that the oysters are buried without chance of securing an air-hole, they must perish. In France it is customary, where the ground is very soft, and the oysters sink, to raise them every two or three months, and replace them on the surface. In such cases, however, the oysters are usually put up for fattening, not for breeding, though oysters breed well enough either on mud-lands or weed-beds. When the oysters are only laid on weed-beds to grow or fatten, it is not customary to hoe the weed. The long, wet weed is found to be an admirable protection from the sun.

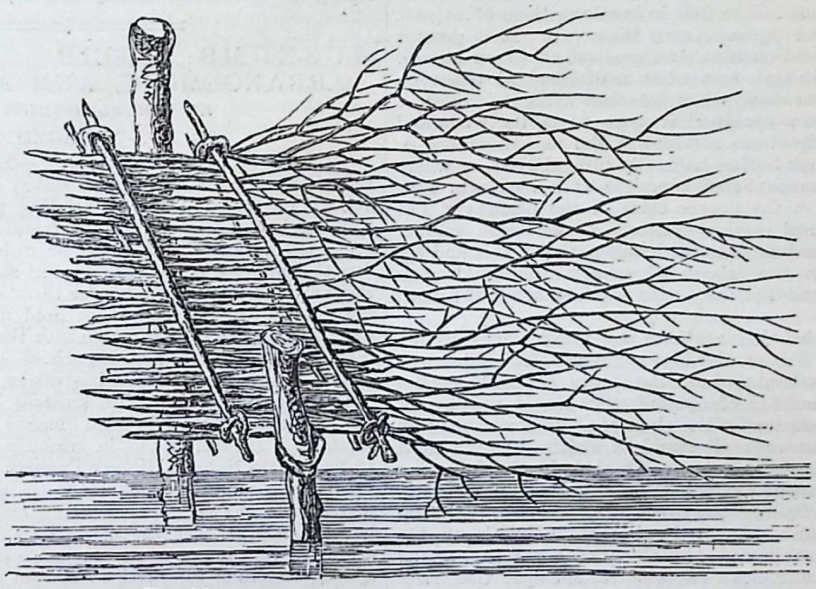


Fig. 28.—HURDLES OF BOUGHS USED AS COLLECTORS.

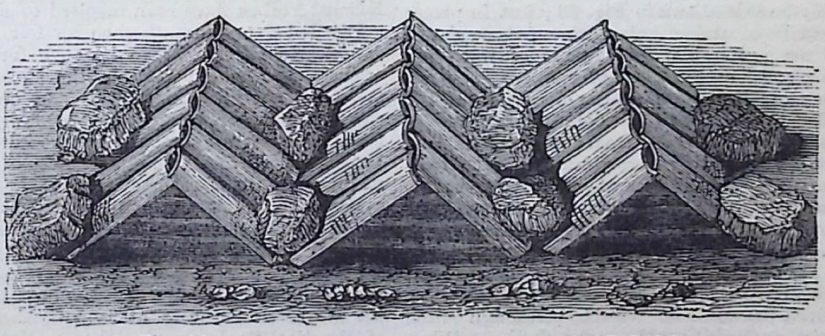


Fig. 29.—TILES PLACED ON A SLOPE AS COLLECTORS.

In Fig. 29 the tiles, it will be noticed, are placed on a slope: this is found advantageous in a strong current. When the tide runs for a long time in one direction, as in some rivers, and when the water is more or less muddy at times, the mud deposits on the back of the tiles, and the spat attaches on the other side.

Fig. 27 is more applicable where the flow is equal, and where as much mud is likely to be deposited by the ebb as the flood tide. The other methods given in Figs. 26 and 28 are employed indifferently in still waters, as in creeks, etc., and in open water, mud-banks, weed-beds, etc., in harbours.

The tank system of oyster culture in reality differs little from that already described, as far as the placing of collectors and oysters is concerned. The fault of many existing oyster-ponds is that they are too small in area, and not deep enough. The longer they are, within reasonable bounds, the better and more natural they will be for the oysters. From three or four acres to ten or twelve is the most useful and the most manageable size, while they should not be less than three feet deep, and should vary to the depth of ten or twelve feet. The water should have free access every tide, save during the spatting of the oysters, when no water should be allowed to escape, lest the spat escape with it. But in very hot seasons considerable evaporation takes place, more particularly in small ponds, and this causes a good deal of disturbance in the density of the water, which is prejudicial. This, therefore, should be carefully watched, and should it threaten to become dangerous it will be advisable to let in a portion of fresh water, if possible.

Weeds are often very troublesome in tanks or ponds, more particularly the green filmy weed *Cladophera*, known commonly as "blanket weed." This is very dangerous to the oysters, and means should be taken to remove it.

It is usual in ponds to gravel large portions of the bottom, in order that provision may be made to catch that portion of the spat which fails to adhere to the collectors; and the shortest time before spatting that this gravel is cast in the better for its

cleanliness. Hurdles and fascines, however, have been found to answer well in such places, and as a large number of collectors is required, they will be found much cheaper. They are fixed in rows by means of pegs, about two or three feet above the oysters, which are scattered on the soil under them, as shown in the illustration, though of course much more plentifully than they are therein depicted (Fig. 27). Furze-bushes (Fig. 26) are also found to answer fairly, and are cheap; but fascines and bushes are scarcely so suitable in a tideway, in consequence of the liability of the twigs to catch weed, break, and float away, when the spat is carried with them. In all cases when wood is employed for collectors, it should be dry, hard, and sapless, and cut at least in the preceding season.

Oysters are more easily detached from wood collectors; the loss by damage to the shell or fish in breaking them off is least upon fascines, as the twigs are easily taken up. It is greater on hurdles, greater still on tiles, and greatest of all on stones. The young oyster, though somewhat malformed at times on twigs, soon regains its shape when detached without damage.

The tank or enclosure method is more particularly adapted for companies or individuals resident in the neighbourhood or the locality where such basins naturally formed exist, or where the enclosure can be rendered complete at a moderate cost. It is not adapted for the poorer class of the peasantry, but still it affords constant employment to a considerable number of persons; and it may be remarked that both for this and the foreshore cultivation the labour of women and children is available, a great portion of the duties required being of a light description.

It has been suggested that as there are many places around our coasts—notably Tralee, Carlingford, Achill, Belmullet, and other localities in Ireland—where the rocks naturally collect each year a large number of oysters, tiles would prove very effective. If too expensive for the class of persons who pick up these oysters from the rocks, it would be worth while for some one to advance the cost, and receive it back in the following year, when the harvest of oysters would enable the peasants to repay the loan; or, failing this spirit of enterprise in the inhabitants, the peasants should be taught to break up the rocks and place them in rows, as already shown in Fig. 25 (page 97), so as to offer clean surfaces for the spat that rises from the bay.

The best arrangements of tiles in such places as Tralee and Bantry would probably be that shown in Fig. 29; but in places where the ground admits of stakes being driven, those shown in Figs. 26 and 28 are preferable. Collectors of wood are unsuitable for such places, catching passing weeds, and becoming slimy and foul, and therefore useless, for it is of the utmost importance that the collectors be clean.

The oyster spats or spawns annually, from the month of May to the month of September; being hermaphrodite, each individual oyster is supposed to produce spawn. The oyster begins to spawn in the third year of its growth, if not earlier. The number of germ or ova brought forth by a single mature oyster exceeds one million. Oyster-spawn, when first ejected, is, in the language of the dredgers, "floatsome," and requires some prominent object to which to attach itself, such as shells, stones, etc., which have received the name of "cultch," although cultch is more appropriately applied to old oyster-shells. When observed in its early stages adhering to the cultch, the spawn has the appearance of spots of tallow, in which the shell is seen rapidly to develop itself, and very soon to form a complete miniature oyster. In this state it is called "spat," 25,000 of which, as nearly as can be estimated, go to the bushel. Spat in the second year is denominated "brood," of which from 4,800 to 6,400 make a bushel. In the following year "brood" becomes "ware," from 1,800 to 2,400 to the bushel; and in the fourth year "oysters" from 1,200 to 1,400 to the bushel. The food of the oyster, with every show of reason, is supposed to consist of minute infusorial animals, with which sea-water abounds. When kept in an aquarium, the oyster is observed to lie with its shell slightly apart, and by means of the ciliary organs or fimbricated margin of its beard, to create a continuous current of water, which thus brings within its reach the nutritive particles of which it stands in need, as well as to pass excrementitious matter, like other molluscous animals.

In the London market oysters are divided into two great classes—"natives" and "commons." Native oysters are those fed in the waters of the Thames estuary and the creeks of its affluents, both of the Kent and Essex sides.

The superiority of the native oyster consists in the relatively large size of the fish compared with that of the shell, its remarkable succulence and delicate flavour, and its compact shape, as well as in the hardness and brilliancy of the shell. The price at which natives sell is accordingly very high in comparison with that of other kinds, and has of late ruled, for oysters of from four to six years' growth, from £10 to £12 a bushel, containing about 1,600.

By the term "commons" are known all other oysters, which, however, are distinguished from each other by the names of the locality from which they are taken—such as Channel oysters, Jersey oysters, West Country oysters, etc.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XV.—MANAGEMENT.

"Trustees" versus "Director."—The government of the British Museum is at present vested by Act of Parliament in a body of fifty trustees, consisting principally of officers of state and nominees of certain families whose ancestors have presented valuable specimens or collections to some of the departments of the institution; but among these fifty trustees there are not more than two or three who take any interest in natural history, nor can these hold direct official intercourse with the general superintendent, or the keepers of the department connected with that branch of science, who have neither vote nor voice in the administration, for all communications have to be addressed to the trustees in official form, through the principal librarian, who makes no pretensions to the name of a naturalist, but in whom, nevertheless, the administration of the Natural History Department is practically vested. With such cumbrous machinery—a capital illustration, by the way, of Dickens's celebrated "How not to do it!"—it is not to be wondered at that the scientific staff has since 1848 been asking in vain for more space—space in any form—and yet the administrators of the British Museum are very jealous of their officers communicating their necessities or ideas to the outer world, otherwise than through them, officially! Well might Edward Forbes have been inspired to sing the un-official lay of "The Red Tape Worm," when he felt how active brains, that saw clearly what *ought* to be done for the onward march of science, were held in check by the stolid drivers of the government engine "Routine," who can only move "slowly but surely," or rather, surely but very slowly, when they take some twenty-five years to make one move in the right direction. In 1862 "the bill to enable the trustees of the British Museum to remove portions of their collections" provided for the present system of administration being transplanted along with the collections themselves; but while the reorganisation of the Natural History Museum is on the *tapis*, it would be well to get rid of the burden of the trustee system, and adopt the simple form of administration which has been found to work so well at the Royal Observatory, at Kew Gardens, and at the Museum of Practical Geology—viz., the appointment of a "Director," who should enjoy prompt and unfettered use and application of the Parliamentary annual grant, for which, together with the general efficiency of the establishment, he would be immediately responsible to one of Her Majesty's Ministers, preferably to a "Minister for Public Instruction," so that scientific authority alone should reign supreme. In so vast and varied a collection, it would be well that a board of management, comprising the keepers of departments in association with the directors should be established, so that the interests of zoology, botany, mineralogy, and geology should alike be fairly represented, to provide against any particular department being developed at the expense of another,* as would probably be the case if one person held despotic sway over any museum embracing all branches of natural history.†

* Opinion expressed by the authorities of the Jardin des Plantes, as quoted by M. Vernueil, before the Parliamentary committee on the British Museum.

† In his report for 1870, Professor Agassiz states that regular conferences have been held among all the officers of his Museum, in

If the present opportunity now offered for so desirable a change of administration is lost, and the old system prevails, then, at least, it should be provided that five out of the fifteen persons who constitute the standing committee of the trustees must be scientific men; further, that both superintendent and keepers should have a voice, if not a vote, on all matters relating to the Natural History Department; that the superintendent should be present at all sub-committees affecting such department, being its official representative, instead of the principal librarian, as under existing circumstances, and the keepers when any question arose that involved discussion.

The late Sir Roderick Murchison, one of the scientific trustees of the British Museum, was of opinion, that some such system, by which the sub-committees could avail themselves of the practical experience and assistance of the heads of the Natural History Departments, in preparing all matters they had to submit for the sanction of the composite or standing committee, would involve a great saving of valuable time.

Appointment of Officers.—Another matter that requires attention is the present method of appointing the officials under the competitive examination system of the Civil Service Commissioners, which has led to some unhappy nominations, and in one case great public scandal, by the notorious incompetence of the person appointed. Naturalists, like artists and poets, "are born, not made." It has been said that schoolmasters class their boys as of a "mathematical," "classical," or "good-for-nothing" turn of mind; but of late it has been discovered that the latter often proves to be the "observing turn," that the old system of schooling never developed into the imago condition of the species *Homo investigator naturæ*. It is curious to note how seldom the mineralogist or chemist, though dealing with the varied forms of crystals he collects or produces in his laboratory, is a good crystallographer. Though a sound observer of the tangible characters of inorganic bodies, the facts of chemical reactions or of physical phenomena, he hands over crystallographic determinations to the mathematician; while the latter (except in the case of the astronomer) seldom deals with the observation of natural objects, much less with anatomical or chemical manipulation, the mind of the naturalist and mathematician being differently constituted, and governed by opposite instincts. Of late years many clergymen have entered the field of practical science; but till very recently the classical minds of our old universities have steadfastly opposed the introduction of science into the college curriculum, often through the idea, the most mistaken of all notions, that science was opposed to religion, regarding it rather as one of the temptations of Satan than as testimony of an omniscient Creator, till forced to waver and then give way before the steady onslaught in the cause of truth led by Adam Sedgwick of Cambridge, and Buckland of Oxford.

Many a youth of a classical or mathematical turn of mind, just fresh from school, and after being crammed by the grinder's art, could satisfy the requirements of the Civil Service Examiners as to his fitness for a gentlemanly appointment under Professor Owen at the British Museum, and, with the friendly influence of one or more of the fifty trustees, might (as has occurred before), without any special fitness as a naturalist, get a berth for life; while it has been said by a friend of Edward Forbes, that had his appointment rested on a Civil Service Examination, he never would have been Professor of Natural History at the School of Mines or at the University of Edinburgh. Professor Agassiz raises his assistants from such students of his class as show capabilities for the work of the practical curator; and young men with such tastes soon make their mark nowadays, and attract the notice of those whose recommendation would receive attention at the hands of the director; and after a probationary term at the Museum, the appointment might fairly rest with him it most concerned to be surrounded by efficient naturalists. The same would apply if it rested with the board of management previously defined. Vacancies should be filled up from the subordinates who had proved the most eminent experts in the branches for which there were openings, and not according to official routine of seniority; maximum of efficiency in the staff being a thing desirable in a national museum.

The Museum Staff.—It is generally acknowledged that the present natural history staff would be insufficient for the work of the new museum, and that there should be re-arrangement of the salaries and duties. Besides the following officers at the annexed salaries—Director-General, at £800, rising to £1,000 per annum; Keeper of Zoology, £600, rising to £800; Keepers of Botany, Mineralogy, Geology, and Elementary Collections, £500 each, rising to £700—there should be Assistant Keepers for Mammalia, Aves, Reptilia, Pisces, Mollusca with Molluscoida, Insecta with Myriapoda, Arachnida with Crustacea, Vermes with Echinodermata, Actinozoa with Hydrozoa, Sponges with Rhizopoda and Infusoria, Botany, Mineralogy, Geology, Elementary Collections, fourteen, at £300, rising to £500 each, with fees arising from their lectures or demonstrations; fourteen corresponding Class Assistants, whose duties would be to sort, make a preparatory diagnosis of new acquisitions, mount, label, catalogue, and arrange specimens after an assistant keeper's identification, and according to his directions and approval, to give out the specimens required by working naturalists, and to supervise the studies to which they were attached, so as to have the disposition of their special collections at their fingers' ends, as initiatory to the higher posts as vacancies occurred, at salaries commencing at £150, and rising to £250 each.

The aim of these student curators should be to devote their studies to such groups as the assistant keepers over them took least interest in, so that every section of the entire collection might meet with its due share of attention. Thus, if an assistant keeper was distinguished for his osteological or anatomical knowledge of a class, it would be well to give him an assistant who was efficient in the zoological or external characters, etc., of that class or group, or *vice versâ*; though it is probable, with the introduction of science-teaching in our schools, and advanced methods of instruction in our colleges, future generations of naturalists will acquire general rather than departmental knowledge—when the term "zoology" shall not mean something distinct from the anatomical, histological, osteological, physiological, and embryological characters of animals, but rather a philosophical blending of these with a knowledge of their external forms, habits, and distribution in time and space. At the present day we cannot point to any system of zoology in the English language that contains such combined information, or even manuals of such a nature on separate classes. Thus we have no such work on the Echinodermata or Annelidæ; and it is to be regretted such contributions as Reay Greene's Manuals on the Protozoa and Cœlenterata, and Woodward's on the Mollusca, have not been followed up by similar useful text-books, wherewith to fill the numerous gaps in English zoological literature. This fact bears rather hardly upon those students who have to undergo the very practical examinations in the important subject of zoology at the University of London.

Professor Agassiz, in his Report for 1870 on the State Museum of Massachusetts, states that "one of the characteristic features of the museum is that all its officers are expected to work seven hours a day for the good of the institution; *no outside work, even of a scientific character, being admitted during that time.* All the officers are now co-operating with me in that spirit. It is no doubt to this devotion to the institution on the part of so many able workers that the museum owes its unparalleled and rapid growth." Might not a hint be taken from this?

Beyond the scientific staff, about fourteen class attendants would be required to supervise the cleanliness of the cases, and conduct of the visitors to the public galleries, etc.; supplemented by men from the corps of sappers, whose services have proved so useful at the South Kensington, and the Exhibitions of 1851, 1862, and 1871, who could serve as a permanent guard, familiar with the plan and ways of the building in the event of fire, to which end one of the non-commissioned officers might be appointed to act as resident fireman, telegraphic communication being established between his rooms and the nearest fire brigade station.

The director would require the services of a secretary to keep the accounts of the departmental expenditure of the museum; a librarian to take general charge of the books, periodicals, maps, etc., throughout the museum; and a resident "guardian" to superintend the traffic, gate and door-keepers,

which they have carefully discussed all questions which relate to the efficiency of the institution.

warming apparatus, etc., and take general charge of the museum day and night, though the fireman would be the acting guardian during the night.

INDIAN RUBBER.—II.

BY GEORGE GLADSTONE, F.C.S.

PHYSICAL PROPERTIES—SOLVENTS—DISTILLATION—CAOUTCHOUCINE—WATERPROOF DOUBLE TEXTURES—SINGLE TEXTURES—SUBSTITUTE FOR LEATHER.

BEFORE proceeding to the details of the Indian rubber manufacture it will be desirable to consider more fully some of its chemical properties. We have spoken generally of its resistance to both acids and alkalis, as well as to water and alcohols, showing it to be a singularly insoluble compound.

The name commonly given to it in France, and which is sometimes used in this country in an English dress, "gum elastic," is therefore altogether inappropriate, as all gums are soluble in water. So misleading a term should by all means be discountenanced.

As to the effect of water, the surface of a piece of caoutchouc blanches somewhat by continued immersion; but whatever may be the cause to which this change in appearance is due, it is practically impervious to water. Mr. Hancock adopted the following plan for testing this point, in the year 1826:—He made a fustian bag with a lining of thin-cut sheet-rubber (such as he was then manufacturing for containing gas), filled it with water, and sealed it up hermetically. It was then weighed, and found to be 1 lb. 1 oz. 4 drams. From time to time it was reweighed, and the date and present weight noted. In the first year it had lost 2 drams; in nine years it was reduced to exactly 1 lb., having during that period lost just 20 drams. During the next nine years the loss was exactly at the same rate, the weight in 1844 being 14 oz. 12 drams. After that period the loss became very rapid, the weights being—

In October, 1849	13 ounces	4 drams.
„ February, 1851	7 „	8 „
„ May, 1854	3 „	14 „

and when it was cut open in 1856, the interior was found quite dry, and the weight of the bag was 3 oz. 12 drams. The test, of course, is not a strictly conclusive one, because it does not account for the proportionally great annual loss after the first eighteen years; but this earlier term of the experiment shows that for practical purposes it may be regarded as impermeable to water.

The alkalis, even when caustic, exercise no action whatever upon caoutchouc, though exposed to their influence during long periods.

The majority of acids, too, especially when cold, produce little or no action. Nitric acid will decompose it to some extent in any case, but when heated it acts with violence. Chromic acid, aided by heat, reduces it to a soft gelatinous mass. Concentrated sulphuric acid acts slightly in the cold, but decomposes it rapidly with evolution of sulphurous acid when heat is employed.

Sulphur itself exerts a remarkable influence, which will have to be described in detail when treating of the manufacture of vulcanised caoutchouc; and the alkaline sulphides produce an analogous result.

The metallic chlorides possess the singular property of rendering Indian rubber even less soluble than it is by nature, by retarding the action of the comparatively few substances which act upon it as solvents.

Alcohol has no effect whatever upon it, and ether will only dissolve it when rendered perfectly free from all admixture of the former by repeated washings: even then it only dissolves a small quantity, and that will be at once precipitated from the solution on the addition of the least quantity of spirit. An ethereal solution on drying will leave nothing but pure caoutchouc behind, the ether separating entirely from the other portion.

Though slowly permeable by gases, they exercise no effect upon it, nitrous oxide forming the only exception. This was first noticed when little transparent balloons, made of a very thin film of Indian rubber, were filled with gas. A balloon thus inflated with hydrogen, or carbonic acid gas, will ere long collapse, and the latter much more rapidly than the former. This led to calculations being made as to the rate of transmission of the various gases. The late Master of the Mint used a septum of Indian rubber in many of his dialytic experiments, and he determined the comparative rate of their transmission into a vacuum on the other side of the septum, the velocity of their passage being as follows:—

Nitrogen	1·000	Oxygen	2·556
Carbonic oxide . . .	1·113	Hydrogen	5·500
Atmospheric air. . .	1·149	Carbonic acid . . .	13·585
Marsh gas	2·148		

His experiments also go to show that the rate is in simple proportion to the thickness of the septum at similar temperatures; but that the rate is considerably increased by an elevation of temperature, at least, within a moderate range. These little toy balloons are distended until the film of Indian rubber is only about one-thousandth part of an inch in thickness; so that for purposes of ordinary use the material may be regarded as perfectly impenetrable.

Indian rubber is therefore a most convenient substance for the experimental chemist. It furnishes him with corks which will be quite tight, and unaffected by most substances; a thin sheet will be readily converted into an air-tight covering for larger vessels; but tubing of assorted sizes is the most useful of all in enabling him, without a moment's delay, to unite different portions of his apparatus with flexible, and, at the same time, perfectly tight joints.

There are, however, certain substances in which rubber is readily soluble, and these are of very great importance, because upon them many branches of the manufacture are entirely dependent. Most of the liquid hydrocarbons possess this property, and especially one which is obtained by the destructive distillation of caoutchouc itself. Benzol is a good solvent; so is the common coal-tar naphtha. Bisulphide of carbon will dissolve about 1 part in 20. Chloroform dissolves it freely. Oil of turpentine, and some of the fatty oils, will also dissolve it readily; but as the latter are not of a drying nature, they do not suit the purpose of the manufacturer. The others which have been named deposit the rubber on drying unaffected in any of its important qualities.

Caoutchoucine, which has just been referred to, is made by distilling Indian rubber in an apparatus specially constructed for the purpose, according to the plan shown in the accompanying diagram. The retort, A (Fig. 3), is made of iron, and is built up in brickwork, with a fire-place below, so that the whole undersurface and part of the sides are exposed to the heat of the fire, before the gases pass on to the chimney, E. A pipe, B, leads from its upper part to the worm, which is placed in the condensing tub, C, the lower end of which is fitted with a stop-cock, D. The retort has a closely-fitting iron cover, F, which is raised and lowered when required by the pulley and chain to which it is suspended. In the cover is a perforation through which a thermometer is passed for the purpose of regulating the temperature. At the commencement of the operation the retort cover is raised; a convenient quantity of common rubber is taken and cut into small pieces, and thrown into the retort, either alone or with not more than one-half its weight of the crude distillate from a previous charge. The cover is then replaced, and the fire lighted. As the thermometer approaches 600° Fahrenheit a dark-coloured liquid comes over, is condensed in the worm, and is drawn off through the stop-cock into a receiver. This is the crude liquid hydrocarbon, to which the above name has been given. As soon as the thermometer is seen to rise again to 600° and upwards, the fire is withdrawn, as the rise in temperature shows that the operation is over. The crude liquid is rectified by distillation, which is repeated as often as desired; at each repetition it becomes more and more volatile and colourless. It can be brought to a specific gravity of 0·67.

The process of rectification reveals the fact that the crude article consists of a combination of different hydrocarbons, as one distils over much more readily than another; and they also possess very different specific gravities. Thus the product of 0·67 specific gravity boils at 90° Fahr., another of 0·69 boils at 104° Fahr., and another, to which the name *hevéene* has been given (from Hevea, one of the synonyms of the Siphonia), is of 0·92 specific gravity, and boils at 599° Fahr.

Caoutchoucine is not only an admirable solvent for the very substance from which it is made, but it will dissolve also all resins, even copal being soluble in it without the application of artificial heat. It mixes readily with oils, and renders cocoa-nut oil fluid at an ordinary temperature.

As the Indian rubber of commerce consisted of very small and irregular-shaped pieces—bottles and the like—the attention of the earliest experimenters was naturally drawn to the desirableness of finding a suitable solvent for it, as being apparently the only means of making these small pieces available in any large manufacture. The application of heat would not answer the purpose, for it melts at 398° Fahrenheit, and unfortunately it does not return to its original condition on cooling, but remains permanently in a semi-fluid and exceedingly sticky state. Coal-tar naphtha, having been found to dissolve it without altering its constitution, was used for making a solution which could be spread over the surface of cloth, and which on drying should leave a perfect film of Indian rubber adhering to it, so that the article should be absolutely impervious to water.

This was the origin of the waterproofing manufacture. It was found by experience, however, that the film deposited from the naphtha had the same sticky surface as the rubber itself when freshly made in the forests of Brazil, and that some considerable time is necessary to dry it sufficiently to get rid of this inconvenience. This would hardly suit the manufacturer on a large scale, as it would involve the erection of an immense range of drying-lofts; and the expedient was therefore adopted of using two cloths, which, being waterproofed on the inner side, became as one substance by the adhesion of the caoutchouc, thus at once avoiding a sticky surface, making an extra strong article of wear, and protecting the film of rubber from the possibility of external injury. For a number of years goods made upon this principle were very largely used by those whose engagements caused them to be much exposed to the weather, though they were heavy and uncomfortable as compared with the manufactures of more recent days, and had a persistent disagreeable smell. This last objection was soon mitigated by the use of a mixture of equal parts of naphtha and the purest oil of turpentine as the solvent; and afterwards still further by using masticated rubber instead of the commercial article, as the former is much more easily dissolved than the crude substance is. The mastication process will have to be described in detail when we come to treat of the manufactures of Indian rubber without the aid of solvents.

The apparatus used in making the above-named class of waterproof goods consists of a vessel in which the solution is prepared, the machinery for spreading it over the surface, rollers for uniting the double fabrics, and a drying shed. A cylindrical vessel 4 feet deep, and the same in diameter, will contain 13 cwt. of caoutchouc, and a sufficient quantity of the solvent, the proportion of the latter being of course dependent on the thickness of solution that may be desired. The caoutchouc is cut into small pieces, and the whole is kept agitated by a revolving stirrer driven by machinery at the rate of sixty revolutions per minute. In the course of three days the article is ready for use. The cloth to be waterproofed is wound on a roller at one end of the gallery, and as it is drawn off from this it is smeared over with a quantity of the mixture, immediately after which it passes between a roller and a horizontal bar adjusted so that there shall only be just enough room for the fabric to pass through; thus the proofing is spread evenly over the surface, and in the case of a single fabric it only needs to remain exposed until dry; two or three coats of the proofing are, however, frequently given to the article, which must be dried between each. Double goods are made by bringing the two coated surfaces into contact, and passing them immediately between a pair of rollers, when they at once unite perfectly: the chief precaution necessary in this operation is to ensure that the two pieces are evenly stretched, or they will not lie smoothly afterwards, and that no creases are made in the rolling, as they cannot be taken out again.

Goods prepared upon the above principle are used for making air or water-tight articles, such as elastic cushions, beds, life-buoys, etc. etc., but as an article of dress they have very greatly gone out of date, a single texture, proofed on one side, being substituted as a much lighter and more agreeable article. When waterproofing was first introduced the stickiness of the surface could never be entirely cured, as the rubber, even after drying, would always retain a certain amount of the solvent. This difficulty has since been obviated by mixing with the solution of rubber a quantity of asphalte and plumbago; or silicate of magnesia with fuller's-earth, whiting, or ochres: the former combination will make a black varnish, and the latter a light one, the tint of which can be varied at discretion by altering the relative proportion of the ingredients. These are spread upon the cloth in the manner already described, and produce a good, glossy, and dry surface.

Various other modes have been devised of using solutions of Indian rubber. It has been employed as a substitute for leather in the manufacture of endless bands for driving machinery, and other articles in which flexibility is of importance. By taking any animal or vegetable fibres, which can be carded or felted, a

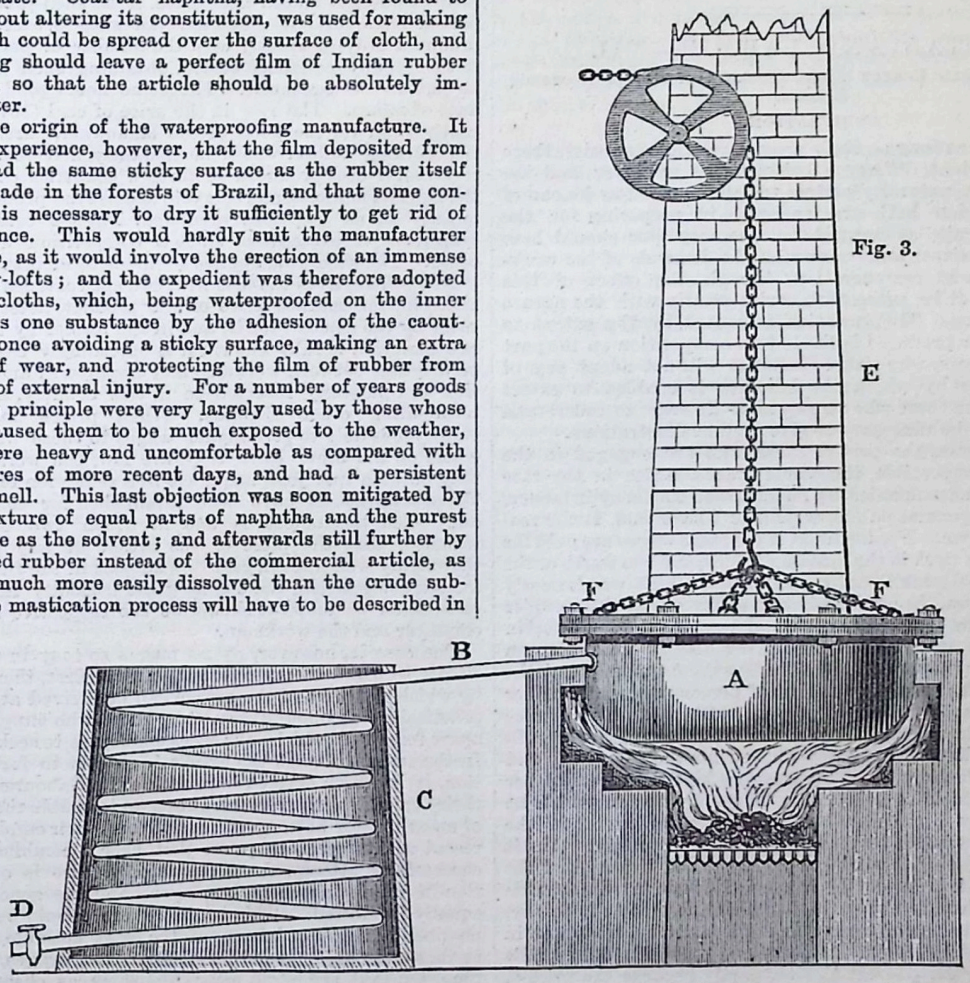


Fig. 3.

strap or sheet of almost any extent can be produced, and this serves as a medium for holding a composition of which caoutchouc is the important ingredient. It is reduced to a liquid by means of the usual solvents, and to this is added strong glue size, resin, ochre, and whiting, in proportions varying according to circumstances. The sheet or band is then saturated with this composition, pressed between boards or rollers, and dried. This operation is repeated until the fibrous foundation is completely permeated and covered by the composition. The article thus prepared has the advantage over leather for many purposes, as any amount of pliancy that may be desired can be ensured by altering the relative proportions of the ingredients; and the elasticity of it can in like manner be regulated by varying the manner of disposition of the fibres.

CAPITAL AND LABOUR.—VII.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

ARBITRATION.

There is, and, as long as their present relations subsist, there will be, a constant difference between the employer and the labourer. Each naturally strives to get as much as he can of the product which both are engaged in preparing for the market. It is quite as natural that the employer should look with great uneasiness and concern on the demands of the workmen for increased remuneration, though the effect of this demand, should it be successful, varies greatly with the nature of the occupation. The variation is caused by the extent to which the article produced is liable to a competition on the part of those producers, who either cannot or will not adopt any of those expedients by which the labourer is enabled to extort better terms from those who employ him. In order to understand this fact, it will be necessary to give certain illustrations.

If competition on the part of those who are engaged in the same labour is impossible, the cost, in case the rise in the rate of wages is not accompanied by an increased efficiency in labour, will fall on the general public, which, as I have said, is the real employer of labour. For instance, if the same wages are paid for fifty-one hours a week in the building trades, and the worth of the work done in the week is not equal to that which was formerly done in sixty hours, the person who will suffer will be the occupier of houses. There is no means, beyond perhaps the importation of joiners' work, by which a foreign or distant producer can compete against the workman on the spot. Assuming that the employer's profit is the same as that of persons engaged in other business, because it requires the same skill in superintendence which is given to other kinds of industry, the employer's profit will not fall. He will reimburse himself for the increased cost of the labour which he hires, by charging his customer a higher price for that which he sells him. The only way in which he can suffer is by diminished business, by a falling off in the number of orders which he receives from his customers. And it may be observed that, as the proportion which the cost of the necessaries of life bears to the income of the man who spends his means for them is always higher when the income is scanty, and as a house is one of these necessaries, any enhancement in the cost of lodging, due to the increased cost of building, falls most heavily on the poorest classes, partly because the price is heightened directly, partly because it is raised indirectly, since there is greater competition for the lowest priced houses.

Again, the object produced may be one which is open to free competition from countries where labour is less costly. Take for example cotton yarns. Now it is quite true that the product of every country is naturally protected by the cost of carriage against the product of any other country, as well as by other causes, which need not be referred to here. But this cost may be, as in the case to which I have referred, very small. If, therefore, British labour were more costly, or to use another expression, less efficient than, say, French labour, it might be the case that British yarns would be in unfavourable competition with French yarns, and thereupon both employer and workman might seriously suffer. This has not yet been the case, for workmen are fully alive to this risk, and apart from the fact that they do not make a demand which is suicidal, labour-saving expedients are constantly lessening the risk. Still it is a risk, and is certainly felt to be a hindrance to those who attempt to obtain better terms for their labour by means of trade combinations. Hence, one of the latest schemes by which the advocates of increased rates of workmen's wages have striven to meet this risk, is that of making trade-unions international, so as to attempt simultaneous action in different countries.

If, in the third place, the object on which labour is engaged is one which can be freely imported from abroad, and is a product of the soil, any increase in the cost of the workman's labour would fall on those who receive rent. In all agricultural operations, when the farmer's profit and the labourers' wages are paid, the residue of the price of agricultural produce goes to the owner of the land in the shape of rent. If the cost of obtaining this produce is lessened, the rent of land rises; and, by parity of reasoning, if the cost increases, the rent of land falls. This result could not indeed take place, if no such produce were imported from foreign countries. In such a case, the quantity produced tallying exactly with the number of persons who subsist on it, any enhanced cost in obtaining such produce would be put on the consumer. The same holds good with the produce of mines. The rise in the price of coal (1872), which has partly been for the good of the landowner, partly for that of the working collier, would be instantly arrested, and speedily reversed, if coal produced in foreign countries could come into the English markets, and compete against the produce of English mines. If, as has been predicted, English coal mines show symptoms of exhaustion, such a competition will ultimately occur. The same rule applies to mines of metals.

Now where, as is the case with two such articles as cotton yarn and iron, the market price of the product, determined in both cases by the demand for it, and in the former by the cost of the raw material, is fully known, it is exceedingly easy to arbitrate on disputes between workmen and employers; and such arbitration is constantly resorted to in this country, as a means of terminating other disputes. When prices rule high, the employer is able to give higher wages to those whom he hires; when, on the other hand, they are low, the workmen must, if they be wise and just, acquiesce in a reduction of their wages. These arbitrations have been established for some years past, and when the object is one in which two conditions are satisfied, that the price of the article at any given time is thoroughly well known, and it is subject in the fullest extent to foreign competition, there is no great difficulty in arriving at a calculation as to what should be the respective shares of the employer and the workman.

The case is, however, by no means so easy in the other two classes to which I have referred. In the first, there is no means by which the price of the article can be arrived at, and there is practically no competition among those who supply the article, apart from that which influences employers to seek for business. In the second, though the article is subject to foreign competition, it has been deemed improbable that labourers could state their demands with so much effect, as to enable the introduction of an arbitrator between themselves and their employers, though recent events seem to prove that such a combination may be successfully attempted. Undoubtedly there is one consideration in which labourers, employers, and the general public are equally interested. This is that there should be the greatest possible efficiency of labour, at the least possible cost of effort to those who are engaged in labour. Low wages, it cannot be too often said, are by no means the same as cheap labour. It can hardly be possible that with such rates of agricultural wages as are said to prevail in some southern English counties, the labourer can possess the heart and strength which are essential towards his being a good workman. If so, it is certain that a rise in the rate of such wages would be no loss to the employer, and a great boon to the labourer.

That some arbitration, settlement, or arrangement, which shall be based on the greatest possible efficiency of the labourer, should be aimed at, is plain from considerations which affect the general public. To this body every person belongs, or in other words, everybody consumes, and pays for, either in his own person or by those who do it on his behalf, those products of labour which he requires for his convenience or necessity. Now it is possible to conceive the extreme case of a general rise in the cost of wages, unaccompanied by any increased efficiency of labour. To make the case still more clear, let us imagine that this simultaneous rise were brought about by a personal action on the part of labourers, and that all shared in the process.

From the point of view which I have been taking in these papers —and which is, I think, incontestable—the employer, being paid wages for his work of management, would inevitably share in the rise which has been effected. Both employer and workmen thus get a higher remuneration in money than they did before the operation which they undertook. But money is not necessaries and conveniences; it is the means for procuring those articles which are the products of labour; the price, therefore, of any article would, in the case which I have stated, rise. The effect then would be that people would have, with great pains, and after a very hot and angry struggle, come round to exactly the same point from which they started, only finding this, that though they got more bits of gold and silver, the increased number would go no further in purchasing goods than the smaller number went to.

TECHNICAL DRAWING.—LXXXIII.

WOODS USED IN CABINET-MAKING.

MAHOGANY (*continued*).

THE mahogany is a graceful tree, with many branches, which form a very handsome head. The leaflets are placed opposite to each other in pairs, mostly four, and sometimes three, but very rarely five, without any odd leaflet at the point; they are smooth and shining, lance-shaped, entire at the edges like those of the laurel, and bent back; each leaflet is about two inches and a half long, and the whole leaf is about eight inches. The flowers are small and whitish, and the seed-vessel has some resemblance to that of the Barbadoes cedar; hence some botanists have given the name of cedar to the tree.

It so far corresponds with the pine tribe, that the timber is best upon the coldest soils, and in the most exposed situations. When it grows upon moist soils and warm lands it is soft, coarse, spongy, and contains sap-wood, into which worms will often eat. That which is most accessible at Honduras is of this description: and therefore it is only used for coarser works, or for a ground on which to lay veneers of the choicer sorts. For the latter purpose it is well adapted, as it holds glue better than deal, and when properly seasoned is not so apt to warp or to be eaten by insects. When it grows in favourable situations where it has room to spread, it is of much better quality, and puts out large branches, the junctions of which with the stem furnish those beautifully curled pieces of which the choicest veneers are made. When among rocks, and much exposed, the size is inferior, and there is not so much breadth or variety of shading, but the timber is far superior, and the colour is more rich. The last description is also the strongest, and is therefore the best adapted for chairs, the legs of tables, and other purposes in which a moderate size has to bear a considerable strain.

Since the produce of Jamaica has been nearly exhausted there are only two kinds known in the market—bay-wood, or that which is obtained from the continent of America, and Spanish-wood, or the produce of the islands chiefly of Cuba and Hayti. Though the bay-wood is inferior to the other both in value and in price, it is often very beautiful, and may be obtained in logs as large as six feet square. It is, however, not nearly so compact as the other; the grain is apt to rise in polishing, and if it be not covered by a waterproof varnish it is very easily stained. It also *gives* to the tool in carving, and is not well adapted for ornaments. Spanish-wood cuts well, takes a fine polish, resists scratches, stains, and fractures much better, and is generally the only sort upon which much or delicate workmanship should be expended. The colours of mahogany do not come well out without the application of oil or varnish; and if the best sorts be often washed with water, or long macerated in it, they lose their beauty, and become a dingy brown. The red is deepened by alkaline applications, especially lime-water, but strong acids destroy the colour. When the surface is covered by a colourless varnish which displays the natural tints without altering any of them, good mahogany appears to the greatest advantage.

The *Febrifuga*, or East India mahogany, is a very large tree. It grows in the mountainous parts of central Hindostan, rises to a great height, with a straight trunk, which towards the upper part throws out many branches. The head is spreading, and the leaves have some resemblance to those of the American species. The wood is of a dull red colour, not so beautiful as common mahogany, but much harder, heavier, and more durable. The natives of India account it the most lasting timber that their country produces, and therefore they employ it in their sacred edifices, and upon every occasion where they wish to combine strength and durability.

The *Chlorolxylon* is chiefly found in the mountains of the Sircars, that run parallel to the Bay of Bengal, to the north-east of the mouth of the river Godovery. The tree does not attain the same size as either of the former, and the appearance of the wood is different. It is of a deep yellow, nearly the same colour as box, from which it does not differ much in durability; and it could be applied to the same purposes.

(*) "African mahogany (*Khaya Senegalensis*), from Gambia, is a more recent importation; it twists much more than either of the above, and is decidedly inferior to them in all respects except hardness. It is a good wood for mangles, curriers' tables, and other uses where a hard and cheap wood of great size is required. It admits of being turned equally as well as the others."

PINE.

(*) Pines and firs constitute a very numerous family of cone-bearing timber-trees that thrive the best in the cold countries. The woods differ in colour, partly from the greater or less quantity of resinous matter or turpentine contained in their pores, which gives rise to their popular distinctions, red, yellow, and white firs or deals, and the red, yellow, and white spruce, or pitch pines or larches. They are further called by the countries or the ports from which they are shipped, as Norway, Baltic, Riga, Dantzic, and American timber, Swiss deal, etc.

WALNUT.

Before the introduction of mahogany, the walnut was the cabinet-makers' tree in England, and it was well adapted for the purpose, being tough and strong in proportion to its weight, beautifully variegated, admitting of a fine polish, durable, and obtained in sizes sufficiently large. In many parts of the Continent, where the expense of the carriage of mahogany is great, the walnut is still extensively used in the manufacture of furniture; and perhaps there is no native tree which bears the climate of England well that is better adapted for the purpose. Oak, though abundantly durable, cannot be finely polished without great expense, and it is heavier in proportion to its strength.

Within the last few years another change has taken place, and walnut furniture has again become popular. Fine old specimens of chairs, cabinets, tables, etc., that had been quietly resting in the lumber-rooms of large mansions, have been brought to light, repaired, and polished, and either reinstated in their former places, or sold at extremely high prices. The great demand for these antique specimens of furniture has naturally led to the resumption of the manufacture of similar articles; and hence we find that in drawing-room furniture especially walnut is now very extensively employed. One circumstance that has contributed to the renewed popularity of walnut is the revival of a taste for marquetry or inlaid work, for the lively and variegated colours of which this wood forms a very appropriate ground.

Of the walnut-tree (called by the Romans "Juglans," or the nut of Jove) there are very many species enumerated, which have been divided by modern botanists into three genera. Of these species it is necessary to mention only two as timber trees—the common walnut-tree (*Juglans regia*), and the white walnut, or hickory-tree (*Juglans alba*). The first of these is a native of the warmer parts of Europe, or perhaps of Asia, and the last is a native of America.

As is the case with all trees and plants that have been long known, esteemed, and cultivated by man, the original country of the walnut is not recorded. Some are of opinion that it is the "Persian nut" mentioned by Theophrastus, and that therefore Persia is the country from which it was first introduced into Europe. It is found indigenous in the more northern parts of that country, towards the mountains of Caucasus; sometimes, though more rarely, in the Russian territory on the north of those mountains; and in China. In all these situations it grows, according to the best authorities, in a state of nature, and propagates itself without cultivation. In the east of France, the south of Germany, and Switzerland, it is very abundant, more especially in Germany, in many parts of which,

such as the plains of the Bergstrasse, which run parallel to the Rhine, between the Neckar and Maine, there is hardly any other timber. In England there are still a good many trees scattered over the country; but the number is not so great as formerly, the partiality for the woods of the colonies and other foreign countries having diminished the value of this, as well as most other species of domestic timber used for finer purposes.

There is still, however, one use to which the walnut-tree is applied, in preference to any other timber, and this use demands the qualities of beauty, durability, and strength: walnut-wood is employed for the stocks of all manner of fire-arms. Before it is used, however, it should be well seasoned, or even baked, as when new it is very apt to shrink, a disadvantage which is completely got rid of by this process.

The walnut grows rapidly until it attains a considerable size, but the absolute duration of the tree has not been ascertained with accuracy: probably the most profitable age for cutting it is the average of hard-wood trees—about fifty or sixty years. There are several varieties of the common walnut, as the thick-shelled, which affords the best timber, and the thin-shelled, which has most fruit and yields most oil. The form which the branches of the walnut-tree assume is generally beautiful. In May the warm hue of its foliage makes a pleasing contrast with other trees, but it opens its leaves late, and drops them early.

PINUS SYLVESTRIS.

The white walnut, or hickory, is a native of North America, where it grows to be a timber-tree of considerable dimensions. One part of the wood is more porous than that of the walnut, but the other is more compact. This gives the grain of the wood something the appearance of that of ash; and where it abounds it is used for similar purposes—the small shoots for hoops, and the grown trees for agricultural implements. Hickory is very tough and elastic, and therefore it answers remarkably well for fishing rods, the shafts and poles of carriages, and other purposes where a slender substance of timber has to resist sudden jerks or strains. In favourable situations, the hickory grows well in England; the specimens in the arboretum at Kew Gardens being of great size for their age, and very handsome trees. The trunk rises to a considerable height, of nearly uniform thickness, as straight as a line, and without any lateral branches.

Lance-wood (*Guatteria virgata*) is a native of the island of Jamaica, and though it does not grow to a very great size, it is perhaps one of the most valuable timber-trees in the island. No timber possesses in a higher degree the quality of toughness and elasticity, therefore none can be better for the shafts of light carriages, and every other purpose where a small body and weight of timber is required to stand a great strain. The very best ash, the toughest of our native timber, is greatly inferior to lance-wood, both in strength and elasticity; and in consequence of ash being open and varied in the grain, while lance-wood is close and uniform, it does not carve so well into ornaments, take so smooth a polish, or admit of being varnished with so little labour.

The hassagay-tree (*Curtisia faginea*) is a larger growing tree than the lance-wood, being one of the largest timber-trees in Africa. Its leaves resemble those of the birch; the timber is compact, firm, and stiff. It is not so much used in this country as the former.

(*) "The royal or common walnut is a native of Persia and the north of China. Walnut was formerly much used in England before the introduction of mahogany. The heart-wood is of a greyish brown, with black-brown pores, and often much veined with darker shades of the same colour; the sap-wood is greyish white. Some of the handsome veneers are now used for furniture, but the principal consumption is for gun-stocks, the prices for which in the rough vary from a few pence to one and two guineas each, according to quality. An inferior kind of walnut is very much used in France for furniture, frames of machines, etc.; it is less brown than the fine sort.

"The black Virginian walnut is a native of America, and is found from Pennsylvania to Florida. It is a large tree, has a fine grain, is beautifully veined, and is the most valuable of the American kinds for furniture."

FISH CULTURE.—XIII.

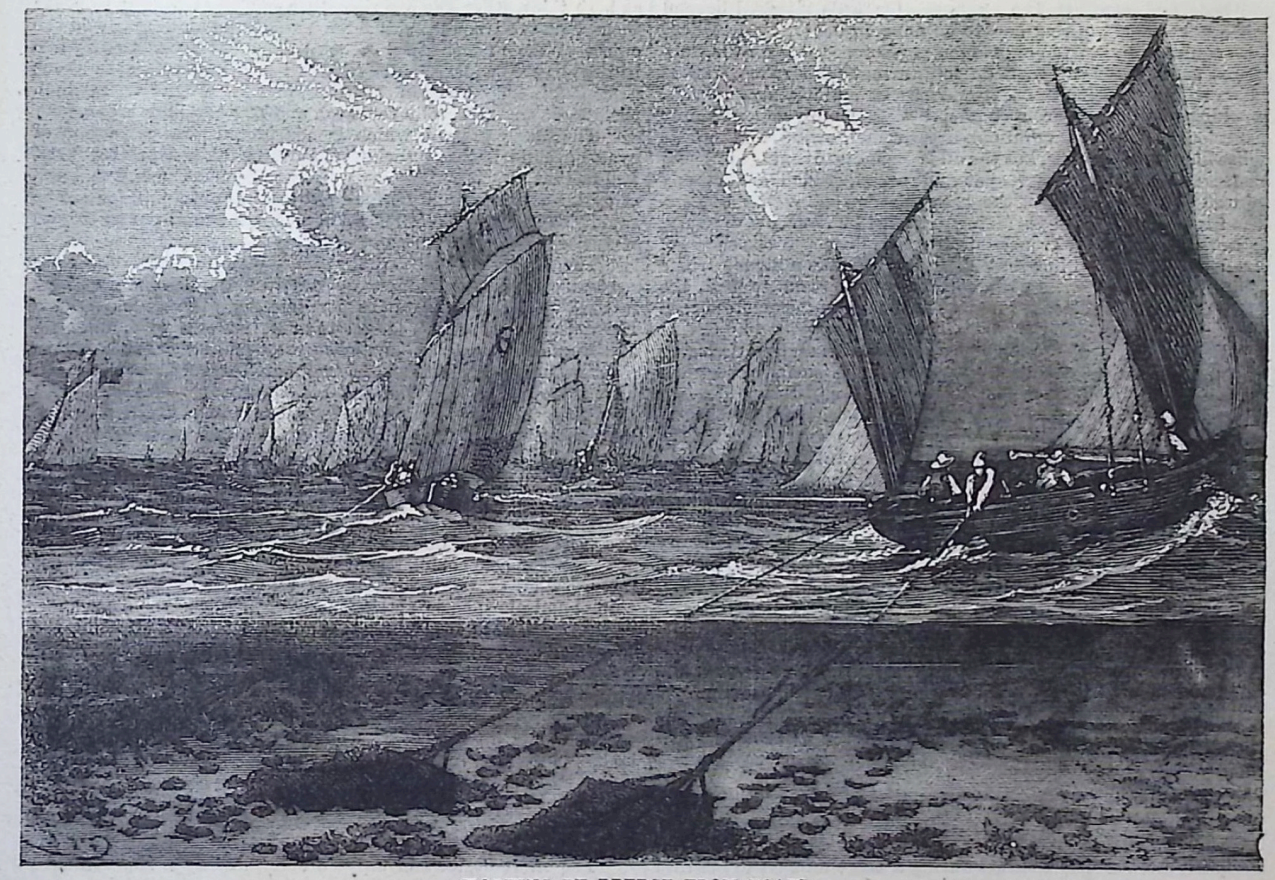
By Greville Fennell.

WHITSTABLE OYSTERS—NATIVE GROUNDS—PRIVATE OYSTER-BEDS—LICENCES—NATURAL AND ARTIFICIAL OYSTER-BEDS—WORKING—REPORT OF MM. NICOLLE AND LE HUGUET ON THE FRENCH OYSTER FISHERIES.

It is impossible at present to say to what cause or combination of causes is to be attributed the great superiority of natives over all other oysters. The most remarkable circumstance connected with the native beds is that they are all situated on the "London clay," or on geological formations of similar character. Beginning on the Kent shore, the native beds extend westward at irregular intervals from Ramsgate—the modern representative of Roman *Rutupia*, celebrated in ancient times for its famous "Rutupians"—to Sheerness and Queenborough, and eastward on the Essex coast and its rivers from Leigh to Harwich harbour. Oyster-beds in every other part of the country are considered beds of common oysters. Many of the best known beds of native oysters are, to a very great extent, factitious. They possess no certain power of reproduction, and would soon become exhausted, unless supplied with brood from other beds better situated for the retention of spawn and the production of spat. Of this kind are the celebrated Whitstable oyster-beds, where a good fall of spat is a mere accident, which, however, sometimes puts as much as £30,000 in the pockets of the Whitstable Oyster Company in one year, by rendering the purchase of brood unnecessary. No artificial contrivances of any kind are in use on those beds for saving the spawn, which is left to settle by chance on the cultch of the beds or on the adjoining foreshores, or else to be drifted off to sea and lost.

Certain of the native grounds—as, for instance, "The Pont" at the mouth of the Colne and Blackwater rivers—are, on the other hand, remarkable for furnishing an apparently inexhaustible supply of spat, from which, in the shape of brood, the Whitstable and other Kent and Essex oyster-beds are mainly kept stocked. This product, so precious for the maintenance of the Thames oyster-beds, has recently risen greatly in value, having been sold in the seasons of 1862-63 as high as 40s. per bushel, and during late years considerably more.

Private oyster-beds are those which from time immemorial have been in the exclusive possession of individuals or companies, and are marked out by buoys or other boundaries. All other oyster-beds are public property, and open to all. On account of the present state of the law in England relative to navigable waters, the existing private beds, being situated below low-water mark, are limited to those of ancient date, because there exists at present no power to restrain any one from appropriating oysters bred naturally or laid down in places not held by prescriptive or other recognised right. In Ireland, however, the Commissioners of Fisheries have been recently empowered to grant licences, under the Crown, for the exclusive right of growing and fishing oysters in places suited for the purpose, to which no prior claims are found to exist.



WORKING BY DREDGE FROM BOATS.

The same state of things exists with regard to the foreshores, of which the Crown claims to have control, with exception only of such as have been ceded by grant or otherwise. In certain districts, and more particularly in the estuary of the Thames, the Crown has to a very great extent lost or disposed of its rights to the foreshores, which have consequently become the private property of the adjoining landowners. In places where this is the case, the foreshores are in general carefully preserved by their proprietors, for the sake of the periwinkles, cockles, and mussels which they produce, as well as for the laying during the summer months of common oysters to fatten for sale in the following season. Natural beds, properly so called, are for the most part beds of common oysters, and generally public property. They are always situated beyond low-water mark, and are seldom covered with less than three

feet of water at low ebb. Some beds of native oysters, however, are true natural beds: to this category belong the principal Colne grounds. But those beds which require to be kept in stock by the laying down of extraneous brood cannot be reckoned truly natural. The latter hold an intermediate position between natural beds, properly so called, and those of strictly artificial character, none of which have hitherto been formed in this country. Artificial oyster-beds, properly so called, are those in which reproduction is secured by artificial means. With the single exception of the ancient Roman oyster-beds, situated in the Lake of Fusaro, they are of modern creation.

Working is an operation by which the oysters are greatly improved. It consists in detaching the brood from the cultch, separating young oysters when joined together, destroying star-fish, dog-whelks, and other vermin, as well as in removing, by stirring it up, the ooze, or "sludge," which is liable to settle on the beds and smother the oysters. On beds situated beyond low-water mark working has to be done in boats, by dredging, and requires as many as eight men per acre. Beds on the fore-shores are worked by men on foot, armed with rakes, two of whom suffice to keep in order one acre of artificial oyster-beds. Working by dredge from boats, besides being less certainly efficacious than working on ebb-dry ground, owing to the beds being hidden from view, has the additional disadvantage of being destructive to the tender spat and brood, which are readily injured by the passage of the heavy dredge along the bottom. The illustration in the preceding page will show how dredging or working by dredge from boats is carried on, and the shape of the dredge employed in oyster fisheries, which is a strong frame of iron furnished with a scraper at the bottom to tear the oysters from the bed, and a net which receives the oysters torn off by the scraper.

Frost, which is destructive to oysters, is prevented injuring the stock on artificial beds by arranging the surface in such a way as to retain about a foot of water at ebb-tide. The experience of the French in this respect is borne out by that of the proprietors of some of the foreshores where spat falls naturally from time to time in uncertain quantities. They find that such spat can always be preserved and reared, even in the most severe winters, on those portions of their grounds where the water, when at its lowest, lies a foot deep, or even less.

The average rate of reproduction obtained in France by artificial breeding arrangements is about fourteenfold, which, after paying expenses, leaves a clear profit of 1,000 per cent. Though affording an extremely handsome return, this result still exhibits an enormous amount of waste, which further improvements in the means of arresting and fixing the spawn will no doubt greatly lessen, and to that extent augment the profits to be derived from artificial oyster-breeding.

The following is an abstract of a report made by Messrs. Nicolle and Le Huguet to the committee appointed by the States of Jersey to inquire into the condition of the French oyster fisheries:—

"On the island of Ré an incredible quantity of oysters has been produced on a sea-shore which a few years ago was of no value, so that this branch of industry now realises extraordinary revenues, and spreads comfort among a large number of families who were previously in a state of comparative indigence.

"At St. Martin the authorities have established model oyster-beds, where we saw the upper parts and sides of stones covered with oysters, in numbers almost incredible, and of remarkable beauty. At low water, when the beds are uncovered, the sight is magnificent. Here we made the acquaintance of Dr. Kemmerer, a man of some standing, who employs much of his time in the breeding of oysters, and who has published a work of a very interesting nature on the subject. It appears that this industry, which now forms a source of great riches for that small place, only dates from 1858. In the short period which has since elapsed upwards of 2,000 beds have been formed on an extent of five miles of foreshore. These beds, of 30 yards square, cost £12 each for their construction.

"The Commissary of Marine at Teste, in the Bay of Arcachon, conducted us to some beds which are very prosperous, and where workmen were employed in detaching the young oysters from each other, in order to give them room to grow. We met the proprietor of one of those beds, who had laid down on them 500,000 oysters scarcely three years ago, and he now estimates the return at not less than 7,000,000.

"We then visited St. Brieuc, where hardly two years since parent oysters were deposited on beds which had become exhausted. Already a single bed has yielded 17,000,000 of young oysters, besides a multitude of others of smaller size."

The fattening of oysters in "claires" is thus described by MM. Coste and Kemmerer, and forms a distinct industry to that of breeding:—

"At Marennes, the mud-ponds, called 'claires,' resemble so many fields overflown with water, established in different places along the two banks of the river Seudre, extending over several leagues along the shores, and forming an immense estate, where a curious and lucrative trade is carried on, the State sanctioning its development by concessions of ground made to fishermen who wish to cultivate it. The 'claires' differ from the ordinary oyster-parks, or breeding-ground, because they are not submerged as the parks are at each tide, but only at high tides, when the sea rises to a sufficient height to cover them, as a too frequent submersion would be an obstacle to the object of the undertaking. Each 'claire' is from twenty-five to thirty yards square, surrounded with a bank of earth about three feet in height and in thickness, forming a dyke upon which the guards walk, thereby to watch and protect their work.

"The marly ground, which is considered the perfection of oyster-ground, is that on which the oyster takes a perfect form, and fattens quickly. We say quickly, because the end and aim of oyster-culture should be for the oyster to obtain perfection as rapidly as possible. We should consider the mud-ponds only as requisite for the growth and fattening the oyster.

"The oysters on the rocky shore are meagre, not very agreeable in taste, and have no nutritive qualities. But they fatten these oysters in parks for sale for all the markets of Europe, under the name of oysters of Ostend, Cancale, Dunkirk, and English natives. When this oyster is fattened it is agreeable to the palate, but still has no positive nutritive qualities. This shore-oyster, however, has had the honour of being cited by Pliny, Cicero, Horace, and Seneca; they were eaten in large quantities by the Africans and Chinese. Our modern people of Paris eat 132,000,000, costing 2,214,344 francs (£88,573). The Roman Sergius entertained the high society of Rome upon them. Marshal Junot ate three hundred before breakfast. But the culture of this oyster in the mud-ponds and in the marl—a culture which ought, some day, to become general—changes completely its qualities, the albumen becomes fatty, yellow or green, oily, and of an exquisite flavour. The animal and phosphoric matter increases, as does the osmazome. This oyster, when fed, becomes exquisite food. In effecting the culture of the sea-shores, and of the marl-ponds, we are pursuing a practical principle of great importance, by the conversion of millions of shore-oysters (squandered without profit) into food for public consumption. The green oyster, to this day, has only been regarded as a luxury for the tables of the rich, but we would like to see it used for food for every one.

"We have proved that the mud-ponds are feeding-grounds to which all the young oysters should be conveyed, and in which are found all the requisite elements for bringing them to perfection.

"The shore-oyster can only be eaten during a few months; the oyster of the mud-ponds, on the contrary, can be eaten during nine months. We thus double the quantity of oysters for the public consumption. Government does not hesitate to modify the law on this point. When we have learnt how to cultivate oysters, the shores will have their crops of these valuable mollusks from Médoc to Bordelais.

"When you wish to partake of oysters, you may seek in the mud-ponds, so justly renowned, of Ars and of Loix to obtain the oyster which is unrivalled, and you will then know the exquisite and unctuous taste which this excellent mollusk gives.

"In the marl the young oyster finds plenty of food, constant heat, and perfect quiet; wherever there is mud and sun, there will be found the little mollusks, crustacea, and swarming infusoria, which are the food of the oyster. This is the ground on which they will grow the quickest.

"In cultivating only the oyster-seed upon the shores, you will have two elements of success in your industry; the first, in saving a great part of the young, which would otherwise be destroyed; the second, in making saleable oysters in three years at the most, when four years are necessary for the oysters in the slimy parks."

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

XVI.—FINANCIAL DETAILS—ADMISSION TO STUDIES.

Financial Details.—It is remarkable that no uniform system prevails at our public scientific institutions for payment for acquisitions. At one museum the curator is at liberty to purchase at discretion any specimens he approves "on the nail," if under the value of £5; while at another he is allowed to spend £10 a month on his own responsibility. For larger amounts, at one museum purchases are recommended by the curator to the governing council, and if approved are paid immediately after the next council meeting that follows the delivery of the specimens; at another purchases made during the quarter are paid for immediately after the turn of quarter-day; while at the British Museum, both keeper and seller meet with considerable delay, if not difficulty, before a purchase over £10 is effected, much to the disadvantage of that institution, as dealer, collectors, etc., who have once experienced inconvenience, especially those who make but a temporary stay in London, offer their best specimens to those museums which are promptest in settlement, a great number of the collectors being poor men. Thus, a keeper of a department has to make his recommendation of purchase; this has to pass through the hands of the superintendent and the principal librarian before it reaches the trustees; and, as Professor Maskelyne remarked, in his evidence before the Parliamentary Committee, is open to "be smothered on its way," a matter that ought to be provided against by rules, even if such an occurrence is not probable. If the sub-committee of trustees accept the purchase on the keeper's recommendation, the authorisation of the standing committee has to be obtained next, and then the signature of an order for payment, which often entails great delay before a purchase is completed; and if a collection is at last declined, it leads to such dissatisfaction that I have heard collectors say they would never again take specimens for sale to the British Museum.

Another financial arrangement that works objectionably is the system involving the forfeiture of any balance from the previous annual Parliamentary grant to a public institution, if vouchers of payment cannot be produced for purchases authorised under that grant, which might arise through the non-completion of an order. At one institution the period for accounting for the annual grant comes so close upon the time at which that particular institution has to make its application for it, that its officers are forced *to pay* for goods, collections, and specimens which they have been authorised to purchase, before *it is possible* to get the orders for the same executed and delivered, in order to obtain the vouchers of purchase, and prevent the annual grant being lost to them by the bearing of this financial rule on the want of uniformity of system among institutions whose requirements are of an allied character. A board of management, composed of the keepers, under the chairmanship of the director, might determine the amount required for the purchase of specimens, new fittings, books, instruments, etc., in their several departments, to enable the director to make application for such items, in lump, in his annual report. Each department could, on the passing of the grant, be credited in the director's account books, and debited with all purchases made; each keeper being authorised to make direct orders for payment on the director up to the extent of their grant, for all purchases they desire to make, whatever the amount. This simple system might well replace the present cumbrous, tedious, and unsatisfactory manner of effecting purchases, which is at the same time derogatory to the official position of the keepers. The unutilised balances from the several departments might, toward the end of the official year, be disposed of in bulk by the director on any class of objects the circumstances of the moment might dictate to his judgment. Provision should also be afforded for securing the temporary services of any travelling naturalist, who had attained eminence by special investigations, particularly in regard to new species, etc., etc. for the purpose of verifying the museum specimens pertaining thereto, as such verified specimens could afterwards be treated as "author's types," in the same way as Professor Maskelyne judiciously availed himself, a few years since, of the invaluable services of Dr. Victor von Lang, colleague of the lamented Grailick, of the Vienna Mineralogical Museum, for the verification of the crystallographic and optical characters of the minerals under his charge.

It is a question whether the keepers ought not, in annual rotation, to be allowed a grant for visiting foreign collections, museums, etc., connected with their own departments, not only for the purpose of keeping themselves *au courant* with what was doing elsewhere, but with the object of securing specimens by exchange or purchase not otherwise attainable.

A surveyor would report on the cost of repairs, etc., which, with the item of salaries and requisition for desiderata, would be communicated to Parliament in the annual report of the Director.

Admission to the Studies.—In the same manner as tickets are now granted to literary men for admission to the reading-room of the British Museum by the principal librarian, so should tickets for access to the studies be granted to students in natural history, by the Director of the new museum, either on his personal knowledge of their being Fellows of scientific societies, naturalists by repute, or on the recommendation of one of the keepers, assistant keepers, or any member of the staff of a scientific school from their personal knowledge, with one important exception. At the British Museum there is an established rule that persons under age are ineligible for admission to the library. This would be judicious if acted on in the spirit rather than to the letter of the law, if it were intended to give power to exclude youths and girls who only desire access for the purpose of reading novels, love-poems, etc.; but it is used, to my personal knowledge, to the extent of excluding infants-at-law who seek entrance for the earnest purpose of gaining a living.

Two years since I commissioned seven artists to make copies, at the British Museum, from certain works required for the Russian Government, the object of which was explained to the library officials, who, with their usual courtesy, gave every facility for the work being executed, and all my draughtsmen received tickets of admission. Among the number was a young but promising artist, who, after some weeks' work, unconscious of this rule, stated in conversation to an official that he was not yet twenty-one. Unfortunate *lapsus linguæ!*—his ticket was immediately confiscated, and he was deprived of earning from ten to thirty shillings for every copy he could make from works only accessible in a national library. Such a frightful attack of "the red-tape worm" upon an infant is worthy of the attention of the body of trustees; and is worth quoting as a warning to those who may have to frame the rules for the government of the studies not to put any such restriction upon age, as long as youths can bring testimony of industrious zeal for the pursuit of natural history.

In concluding this series of articles on the "Construction, Arrangement, and Management of a National Museum of Natural History," I have endeavoured to show that the ideas of the leading naturalists of the present day could readily be embodied in one building; and it is to be hoped that party feeling will not mar the attainment of this desirable end, but that men of influence will unite with "a pull altogether" in a rational and national spirit to further the excellent intentions of the Government, for it rests with them whether a museum suited to the wants of the age shall now be attained, or the opportunity lost for ever. It would have been more satisfactory if the approved plans had been submitted to a committee of British naturalists before builders were invited to send in tenders for the work to be executed; for on such a very important question it would have been well to know that the plans even of such an eminent curator and *savant* as Professor Owen met with the entire approval of all who have given serious and disinterested thought to this subject, and that such plans left nothing to be desired; especially when, during the present session of Parliament, on an inquiry being made by Lord Elcho as to when the plans relating to another building, the new Law Courts, would be submitted to members interested in the matter, he was informed by Mr. Ayrton that he "had made that inquiry just four years too late," and that the subject could not be reopened. Professor Flower well says, in his article in "Nature," previously quoted:—"Long and extensive experience has, or ought to have, taught us the best principle of construction as applied to libraries and picture galleries; but the natural history sciences are in their infancy as compared

with literature and art, and the best methods by which their treasures can be housed and exhibited have yet to be learned. *The way in which this is done in the new museum will exercise so great an influence upon the progress of these sciences*, that it should not be determined upon without full consideration by those who are most conversant with their present state, and with the probable wants of a future generation of students."

Not even the fear that, by such an elicitation of the opinion of England's leading naturalists, further delay might arise should prevent Government from ascertaining in the most positive manner possible that in those plans all had been provided that could be provided for "arranging, preserving, and exhibiting in a fitting manner a natural history collection worthy of the country as well as of its capital, and intended not only for the special advantage of students and scientific men, but generally for the rational amusement and instruction of all classes;"* for, as Agassiz says, State museums "should be sanctuaries revealing the advances of the sciences, which, by their very perfection, would be a standard measure by which to test the scientific culture of a country."†

SHIP-BUILDING.—XXII.

BY W. H. WHITE,
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THE RIVETING OF IRON SHIPS (*continued*).

In this article we propose to give a brief account of that method of procedure in arranging butt-fastenings which appears, on the whole, to give the best results; and our endeavour will be to make the process intelligible to all readers having any acquaintance with iron ship-building. All, or nearly all, butt-fastenings in an iron ship may be arranged under two heads: the first, those used to connect the lengths of a single strake of plating, such as a deck-stringer or tie-plate, as well as of a single bar of any form; and the second, those used to connect butted plates in an assemblage of plating, like the outside skin, or the plating of an iron deck. For our purpose, therefore, it will be sufficient to take a representative case under each head; and we will begin with a deck-stringer plate, say $3\frac{1}{4}$ feet wide, and $\frac{5}{8}$-inch thick, riveted to the beams with $\frac{3}{4}$-inch rivets, as shown in Figs. 59, 60, 61.

The weakened sections, which are to be our chief guides, in this case occur at the rows of holes in wake of the beams. On reference to the sketches it will be seen that there are seven rivets in each row; hence to find the strength of the stringer at the weakened section we proceed as follows:—

	inches.
Total breadth of stringer-plate . . .	39
Deduct for 7 rivets ($7 \times \frac{3}{4}''$) . . .	$5\frac{1}{4}$
	$33\frac{3}{4}$
Thickness of stringer-plate . . .	$\frac{5}{8}$
Sectional area of plate at weakened section	$21\frac{3}{32}$ sq. in.

Taking 18 tons per square inch as the breaking strength of the stringer-plate after the holes have been punched, we obtain finally—

$$\left.\begin{array}{l}\text{Breaking strength of stringer-plate}\\ \text{at weakened section}\end{array}\right\} = \overset{\text{sq. in.}}{21\tfrac{3}{32}} \times \overset{\text{tons.}}{18} = \overset{\text{tons.}}{379\tfrac{11}{16}}$$

Assuming that the rivets used in the butt-fastenings are to be of $\frac{3}{4}$-inch diameter, we take Mr. Reed's figures of 10 tons for the single shear, and 18 tons for the double shear of each finished rivet; and to ensure the double shear we shall require a butt-strap below as well as above the stringer, while a single butt-strap will suffice to secure a single shear. Obviously, if the butt-fastening is to be as strong as the weakened section, the shearing strength of the rivets on either side of the butt must equal the breaking strength just calculated. Hence we have—

Number of rivets required on each side of the butt:—

$$\text{For a single shear} = \frac{379\frac{11}{16}}{10} = 38 \text{ say.}$$

$$\text{For a double shear} = \frac{379\frac{11}{16}}{18} = 22 \text{ say.}$$

The next question is, what shall be the arrangement of these rivets, and taking into account the breadth of the stringer-plate it becomes obvious that treble-riveting would be required with a single butt-strap. This arrangement is shown in Fig. 60, but it is essentially defective; because it makes the section of the stringer-plate in wake of the row of rivets in the strap furthest from the butt considerably weaker than the unavoidably weakened sections at the beams. A reference to the sketch will make this obvious, for there are no less than thirteen rivet-holes punched in the specified row of the butt-fastening, whereas there are seven only at each of the weakened lines on the beams; and consequently the plate would break across at its weakest section in wake of the outer row of closely spaced rivets, if it were put under tension, long before the strain would be sufficient to shear off the rivets on one side of the butt, or to break the plate across its weakened sections at the beam. This plan, therefore, will not do.

Taking double butt-straps, and consequently a double shear of the rivets, twenty-two only are required, and these might be arranged double-chain fashion, as in Fig. 59; but here again the weakest section of the plate would be found in wake of the row of rivets next the edge of the butt-strap, just as in the preceding arrangement, and consequently this plan is defective.

From these two trials it will be obvious that an essential feature of any proper arrangement must be to make the number of rivets in the rows furthest from the butts not greater than that in each row on the beams. This consideration would, of course, be one of the first taken into account in practice, but we have preferred to enforce its importance by examples. In Fig. 61 it has been applied, and we have at length a satisfactory arrangement of the rivets. Altogether, there are twenty-three on each side of the butt, and their shearing strength, for double shear, is 414 tons—that is, about 35 tons greater than the breaking strength in wake of the beam-rivets. At the rows of rivets furthest from the butts there are only six holes, as against seven at the unavoidably weakened sections on the beams. Other methods of opening the butt under tensile strains may be imagined, but they will be found to involve a greater breaking strength than the foregoing, supposing the butt-straps to be made strong enough to resist fracture. For instance, if the plate broke across at the middle row of rivet-holes in the strap, then the row of rivets furthest from the butt would all have to be double-sheared before the butt could open; and if fracture took place across the more closely-spaced rows of holes nearest the butt, then the two other rows of rivets would have to be double-sheared. The reader can, if he chooses, calculate for himself the breaking strengths corresponding to these two methods of fracture, and will find them both greater than the strength of the unavoidably weakened sections of the stringer.

One other consideration remains—viz., the requisite thickness of the butt-straps. The critical line of fracture for the straps is clearly that through the row of rivet-holes nearest the butt, because if both straps were broken thereat, the butt would be opened. The total length of the supposed line of fracture (rivet-holes being deducted) is $30\frac{3}{4}$ inches; and our first calculation gave $21\frac{3}{32}$ square inches as the sectional area of the stringer at its necessarily weakened section. It will therefore evidently be sufficient to make the sectional area of the two straps at the supposed line of fracture equal to $21\frac{3}{32}$ square inches, and this gives a total thickness of $\frac{21\frac{3}{32}}{30\frac{3}{4}} = \cdot 7$ nearly, rather less than $\frac{3}{4}$-inch, so that ample strength will be obtained if each strap is made $\frac{5}{8}$-inch thick.

With an example of this detailed character before them, our readers will have no difficulty in applying a similar method to other cases where a single strake of plating is used as a longitudinal strengthening—for instance, to the longitudinal frames, the tie-plates on deck-beams, the sheer and bilge strakes of composite ships, etc. etc.; and will be able to deal with the butt-strapping of bars used for keelsons, etc.

Attention must next be turned to a typical case of butt-fastenings for a strake of plating associated with and connected to other strakes, with regard to which its butts are shifted. An example in point is given in Fig. 62, which shows an inside view of a portion of the skin-plating of an ordinary iron ship. We will assume that there are *two* passing strakes between consecutive butts in the same frame-space (as in the shift illustrated by Fig. 36, Vol. III., p. 305); so that it will be perfectly

* Treasury Minute of 1862. † Report of 1860.

fair to consider the passing strakes P and R as assisting the butted strake Q, and to consider those three strakes apart from the remainder of the plating when dealing with the fastenings of the butt A B. Of course, with a different number of passing strakes between consecutive butts, different assumptions would be required, but these need not be discussed here.

It will be assumed that all the plates are $\frac{3}{4}$-inch thick, and $3\frac{1}{2}$ feet broad; also that the rivets are of 1 inch diameter. The strength of the plates in wake of a row of punched holes will be taken as before at 18 tons per square inch of sectional area, and the shearing strength (single) of a 1-inch rivet will be

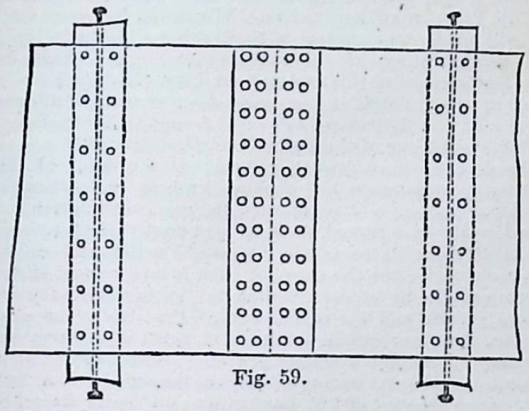


Fig. 59.

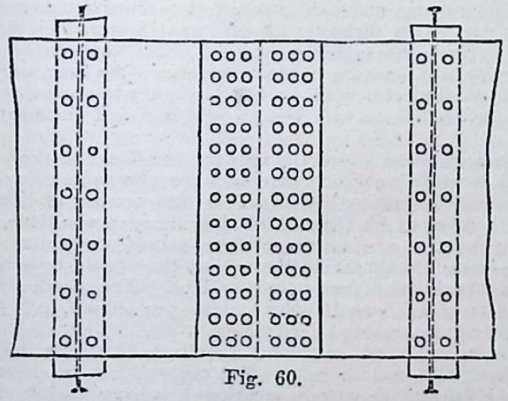


Fig. 60.

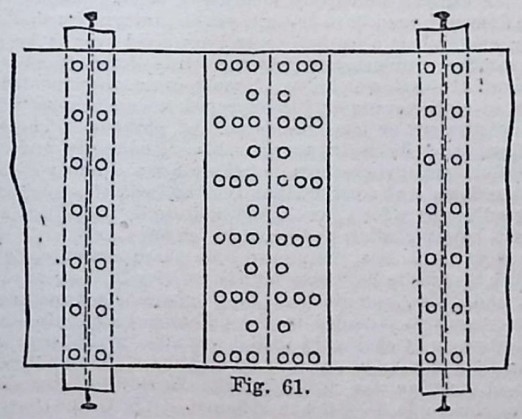


Fig. 61.

taken at $17\frac{7}{9}$ tons (see page 135). For the sake of simplicity also it may be assumed that the frame angle-irons are removed, and the plating alone considered, the necessarily weakened sections (such as C D) being, of course, retained.

Let us first consider how the butt A B is most likely to open under tensile strains, remembering that the edge-riveting between A and E, and B and F, is necessarily arranged in something like the fashion shown in the sketch in order to make water-tight work.

It may open by shearing all the rivets on one side of the butt, and also shearing the edge-rivets just referred to; or it may open by breaking the butt-strap across the row of rivet-holes nearest the butt, and also shearing the edge-rivets. In either case the shearing strength of the edge-rivets helps the butt, and it is this fact which constitutes an important difference between a butted strake in an assemblage, and one standing alone like the stringer-plate previously considered. There are, of course, other possible modes of fracture, but none more probable than the two just mentioned. Assuming for the present that this statement is correct, we will proceed to calculate the

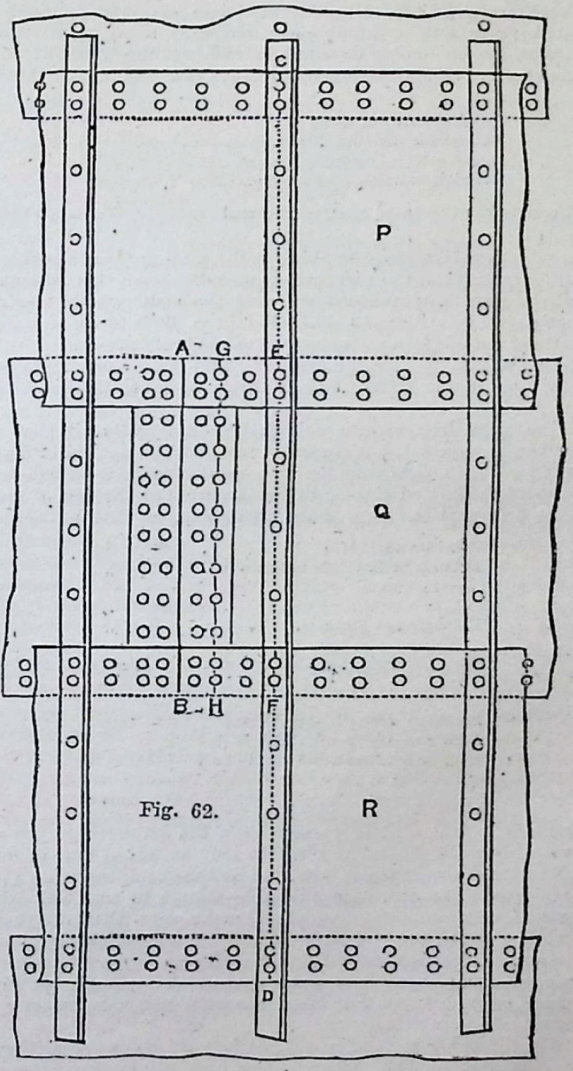


Fig. 62.

strength required in the butt A B to make it equal to the necessarily weakened section of the strake Q (along E F) in wake of the frame. We have—

Total breadth of butted strake Q	42	inches.
Deduct for 7 rivet-holes in line E F	7	"
	35	"
Thickness of plating . .	$\frac{3}{4}$	
Sectional area of Q at line E F	$26\frac{1}{4}$	sq. ins.
	18	tons.
Breaking strength of Q at line E F	$472\frac{1}{2}$	tons.

There are twelve rivets requiring to be sheared in the edges between A and E, B and F, and their total strength $= 12 \times 17\frac{7}{9} = 213\frac{1}{3}$ tons. Deducting this from the breaking strength

just calculated, we have $(472\frac{1}{2} - 213\frac{1}{3})$ say 260 tons, as the minimum strength which should be given either to the shear of the rivets on one side of the butt, or to the butt-strap across the row of rivets next the butt. Hence we obtain the following values:—

$$\left.\begin{array}{r}\text{Number of rivets required on}\\ \text{one side of the butt}\end{array}\right\} = \frac{260}{17\frac{7}{9}} = 16 \text{ say.}$$

$$\left.\begin{array}{r}\text{Sectional area of strap through}\\ \text{supposed line of fracture}\end{array}\right\} = \frac{260}{18} = 14\tfrac{1}{2} \text{ sq. in.}$$

Double-chain riveting will therefore suffice, as shown in the sketch; and to ascertain the thickness of strap required we must make another simple calculation. As Q is an *outside* strake, the butt-strap does not extend over the whole width of the strake, but only between the edges of P and R. So that—

	inches.
Total breadth of strap	30
Deduct for 8 rivets	8
Breadth remaining at supposed line of fracture	22

$$\text{Therefore the thickness of strap required} = \frac{14\frac{1}{2} \text{ sq. in.}}{22 \text{ in.}} = \cdot 66 \text{ nearly.}$$

In other words, a strap as thick as the plating ($\frac{3}{4}$-inch) will give rather more than the strength required. From this example it will be seen how unnecessary were the elaborate devices formerly used (see Figs. 42, 43, Vol. III., p. 352) for securing the butts of outside strakes across the whole breadth; and also that there was good reason for asserting that with the simple plan now used, it was sufficient to fit straps of equal thickness with the plating.

The preceding simple calculations are really all that are commonly required, but we will take another method of breaking in order to show that the arrangement made is satisfactory. Suppose the butted plate Q to break across at the row of rivet-holes G H, next the edge of the butt-strap, we shall have—

Total breadth of Q . . .	42	inches
Deduct for 12 rivets in line G H .	12	"
	30	"
Thickness of plate	$\frac{3}{4}$	"
Sectional area of Q at line G H .	$22\frac{1}{2}$	sq. ins
	18	tons
Breaking strength of Q at ditto .	405	tons
Add for shear of 4 rivets in edges between G and E, H and F	$71\frac{1}{3}$	
	$476\frac{1}{3}$	tons

and this is still a little greater than the strength of the unavoidably weak section at E F. It may be added that in cases where the frame-space is small, as in the example we have just considered (Fig. 62), it is advisable always to test this latter method of fracture, in order to make sure that it gives a breaking strain not less than that of the unavoidably weakened section. Other modes of fracture will also suggest themselves to any person engaged in such work, and it should be ascertained beyond doubt that in all essential respects the arrangement made is satisfactory.

The foregoing method is not put forward as one admitting of no improvement, but rather as the best yet known for use in practice, and as embodying the best data accessible up to the present time. It is identical in principle with that used in the Government service; and in building the ships of the Navy, great care is always taken to have good arrangements of butt-fastenings, combining the required strength with the minimum weight of material.

It is only necessary to remark that the simple plan of calculation just described for the outside plating is as applicable to other assemblages, and is made use of for iron decks, flats, etc. etc. Into the minor modifications necessary under different circumstances it is needless for us here to enter, as any person undertaking the work will experience no difficulty in making the necessary changes. Enough has been said in the course of the present paper to guide any one who is studying these principles theoretically and practically, to the proper method of doing so.

SANITARY ENGINEERING.—XXVII.

THE EFFECT OF SANITARY IMPROVEMENTS UPON THE HEALTH OF THE POPULATION.

BEFORE concluding our present series, which we shall do in our next paper, we propose to lay before our readers some reliable data as to the result of the introduction of improved methods of water-supply and drainage upon the health of the population at large. The question has been the object of Government inquiry during a series of years, and the subject of frequent legislation, into the detail of which, however, we do not propose to go, considering it rather beyond the strict range of THE TECHNICAL EDUCATOR. We think, however, our subject will hardly be complete without some allusion to the practical general effect of the various appliances which, in the preceding papers of this series, have been described and illustrated in as full detail as the space at our command allowed.

Some of our figures are extracted from the Ninth Report of the Medical Officer of the Privy Council, dated 1867.

The diseases most directly referable to the want of efficient sanitary arrangements are cholera, typhoid and other fevers, diarrhœa, and in a less marked degree consumption. With regard to the first named, medical men hold various opinions as to the different forms of the disease, English and Asiatic as they are termed, but the cause of both is now almost distinctly ascertained to be cholera contagium in foul air, foul earth, or foul water; and the report says, "Practically the chain of evil (*i.e.* the progress and spread of cholera) is abruptly broken wherever thorough cleanliness prevails," and a most important element is the pureness of the water-supply. A terrible epidemic at the east end of London was distinctly traced to the fact of a company, under the pressure of peculiar circumstances, having supplied a district with unfiltered water, and this, if not the original cause of the outbreak, had much to do with its development and aggravated character. We may mention that similar neglect now subjects the company to a penalty. In our paper No. XV, on water-supply, will be found other parallel cases.

Cholera, however, happily is only an occasional visitant, but typhoid fever and endemic diarrhœa are always more or less with us; and a striking instance of the universality of liability which is incurred by the neglect of sanitary precautions, has recently been shown in the anxiety caused throughout the nation—we might almost say throughout the world—by a single case in the highest family in the land. The deaths from typhoid fever are from 15,000 to 20,000 per annum, and those from diarrhœa probably as numerous.

Consumption is a complaint peculiarly incident to the English climate, and though its first cause differs in character from the diseases previously mentioned, arising mainly from unwholesome humidity in the air, yet the returns we shall presently quote show a marked control exercised over it by complete sanitary arrangements. In the words of the report, "The drying of the soil, which has in most cases accompanied the laying of main sewers in the improved towns, has led to the diminution more or less considerable of phthisis. These are the three most distinctly recognisable evils directly under the control of sanitary measures, but there are a number of other maladies dependent most materially upon good air, good water, and good drainage for their considerable diminution. Our space will not, however, allow us to go into further detail.

First as to cholera, there have been three recent epidemics of which the results have been noted occurring in the years 1849, 1854, and 1866; and we give the comparative death-rate in various towns as recorded in the different years. In Cardiff the death-rate by cholera in 1848-9 was 208, in 1854 it was 66, and in 1866 it was $15\frac{1}{2}$; it may be mentioned that the medical officer of the town was most efficient. In Newport, the death-rate by cholera in 1848-9 was 112, and in 1866, 12. Sanitary improvements thoroughly carried out in the intervals referred to are to be credited with this marvellous improvement. The cholera rate in Dover was in 1849, 40; in 1854, 10; and in 1866, $4\frac{1}{2}$. At Cheltenham the corresponding figures are 82, 11, and $1\frac{1}{2}$; at Salisbury, 180, $14\frac{2}{3}$, and "perhaps" 1.

We might multiply instances, but think we have quoted enough, our object being to prove the general fact only, not attempting a complete statement of detail. We next take the case of typhoid fever and diarrhœa. Here we have, of course,

no such exact data to guide us as in the case of cholera, but can only give the decrease of the death-rate as obtained by comparison before and after the completion of the sanitary works. In Croydon they fell from 25 to 12½; in Macclesfield, from 25½ to 19½; in Salisbury, from 14 to 4; in Cardiff, before quoted, 17½ to 10½.

In typhoid fever alone the death-rate fell in Warwick from 19 to 9; Penrith, 10 to 4½; Stratford, 12½ to 4; Alnwick, 13⅓ to 8⅔; Morpeth, 16½ to 10; Ashby, 13⅓ to 5¾. The great difference in the earlier figures among the various towns will no doubt attract attention, their situation, soil, and the habits of their population all having their effect upon the general result. Did space allow, some curious facts might be deduced as to the comparative salubrity of different strata and situation.

We now take up our next head, that of phthisis. The reduction in the death-rates is stated as under:—Salisbury, 49 per cent.; Ely, 47 per cent.; Rugby, 43; Banbury, 41; Worthing, 36; Macclesfield, 31; Leicester, 32; Newport, 32; Cheltenham, 26; Bristol, 22; Dover, 20; Warwick, 19; Croydon, 17; Cardiff, 17; Merthyr, 11. Here we should, to complete the comparison, give the previous death-rate, but we content ourselves in this case by merely stating the result. Such are the actual certified results of improved sanitary arrangements, due not only to the introduction of improved methods of drainage and water-supply, but to the efficient organisation of a certain system of inspection and control. Into the details of this organisation we are not proposing to go: we may merely mention that in some of our principal towns it is carried out with almost military completeness and efficiency, and point out the arrangements adopted by the corporation of the City of London as a model in this respect. There is an engineer for the constructional and practical department with an efficient staff of subordinates, a medical officer for the higher branches of hygiene proper, and a large body of inspectors, whose duties are clearly defined and regularly mapped out, exercise a salutary control in their various districts.

But in many of our provincial towns there is still a great deal to be done, and a single case in point we quote from a report just published by Dr. Ballard, who was employed by Government for the purpose, remarking that the conditions he describes are by no means peculiar to Bolton, but would be equally applicable to many other manufacturing towns. Paper-works, dye-works, and various mills discharging their refuse into the rivers; the working classes penned closely together in ill-built, crowded localities; close courts behind the houses sometimes unpaved; the absence of sufficient closet accommodation; and the total want of organised sanitary inspection, have all their share in conducing to the evil, the marked existence of which led to the special inquiry—viz., an exceptionally high death-rate. The greatest cause of mischief is the almost universal use of middens: for 16,000 houses there are only 500 closets; there is a system of main drainage in operation, but it is perfectly clear that under the circumstances it may almost be called a mockery as far as sanitary arrangements are concerned. More than 2,000 houses have been built within the last ten years, mostly of cottage character, and they possess all the worst faults of the lowest character of building—inefficient foundations, utter absence of house drainage, incomplete ventilation, the windows in their lower portion not even made to open, in some cases the sleeping-room of a whole family built without fire-place or chimney—in fact, many of the houses in the town are unfit for human habitation.

From this report, and from much similar evidence at our command, we cannot help drawing the inference that private enterprise will never be sufficient to provide efficiently for the general sanitary arrangements of the country. Much may be done by private and personal efforts by persons in a position to understand and efficiently attend to many of the necessary details of sanitary matters. And we recall the celebrated dictum of a late noble lord, in which he impressed upon the working classes the necessity for their personal attention to these matters; but there is an immense body of the lower portion of the population who have not the knowledge, and even if they had, do not possess the power of protecting themselves. And here we have no doubt of the great desirability of Government interference. The chaos in which sanitary and other legislation and organisation are plunged throughout the country was fully detailed in the Second Report of the Royal Sanitary Commission published last year; and although an analysis of its contents is beyond the scope of THE TECHNICAL EDUCATOR, we strongly recommend its perusal by all engineers, medical officers, and others interested in the subject. The improved health of the localities where efficient sanitary improvements have been carried out, quoted in the earlier portion of this paper, is a most striking fact, and the promotion of such improvements is clearly the duty of each and all of us. The 28th, our succeeding and final paper, will be devoted to a summary of the subject, indicating in a few lines the leading matter of each of this series of papers, embraced under the four heads of Gas, Warming, Ventilation, and Drainage, so that those interested in any particular subject may readily refer to the paper containing the details they require.

TECHNICAL DRAWING.—LXXXIV.

DRAWING FOR CABINET-MAKERS.

WOODS USED IN CABINET-MAKING (*continued*).

ROSEWOOD

Is a wood much employed in cabinet work, but is too expensive for general use; its name is derived from its fragrance, and it has long been known to the cabinet-makers of England and France. It is said to have been first introduced from the isle of Cyprus, though the great supply now comes from Brazil. The wood is too well known to require any description. The more distinct the darker parts are from the purple-red, which forms the ground, the more is the wood esteemed. It is ordinarily cut into veneers for all the larger furniture, such as tables; but is used solid for chairs, small tables and cabinets.

(*) "Rosewood is produced in the Brazils, the Canary Isles, the East Indies, and Africa. It is imported in very large slabs, or the halves of trees, that average 18 inches wide. The best is from Rio de Janeiro, the second quality from Bahia, and the commonest from the East Indies; the latter is called East India black-wood, although it happens to be the lightest and most red of the three; it is devoid of the powerful smell of the true rosewood, which Dr. Lindley considers to be a species of mimosa. The pores of the East India rosewood appear to contain less or none of the resinous matter in which the odour like that of the flower *Acacia armata* arises. Rosewood contains so much gum and oil, that small splinters make excellent matches.

"The colours of rosewood are from light hazel to deep purple, or nearly black; the tints are sometimes abruptly contrasted, at other times striped or nearly uniform. The wood is very heavy, some specimens are close and fine in the grain, while others are as open as coarse mahogany, or, rather, are more abundant in veins; the black streaks are sometimes particularly hard, and are very destructive to the tools."

OAK.

In point of strength, durability, and general application, the oak claims the precedence of all timber, and to England, which has risen to the highest rank amongst the nations through her "wooden walls," it has always been of the greatest importance. Although, since the improvement in our methods of working iron, it is not now so much used for ships as formerly it is still for building purposes and for furniture as valuable a wood as ever.

The oak grows to an enormous size, attaining frequently a height ranging from 80 to 100 feet, with a trunk from 6 to 12 feet or more in circumference. Of this important wood Mr. Holtzapffel says: (*) "Of this valuable timber there are two kinds common to England, and several others to the Continent and America. Oak of good quality is more durable than any wood that attains the same size. Its colour is a well-known brown. Oak is a most valuable wood for ship-building, carpentry, frames, and works requiring great strength or exposure to the weather; also for the staves of casks, spokes of wheels, for tree-nails, and numerous small works. The red varieties are inferior, and are only employed for ornamental furniture. The English oak is one of the hardest of the species; it is considerably harder than the American, called white and red Canada oak, or than the wainscot oak, from Memel, Dantzic, and Riga. The latter, which are the most interspersed with the ornamental markings or flower of the septa, or medullary rings in the wood, are the least suitable as timber."

MAPLE.

Of the maple (*Acer*) there are about thirty-six species, natives of various countries. Six are indigenous to Europe, about twelve to America, and the remainder to various parts of Asia. Most of them are deciduous trees, but one is an evergreen shrub. It will be necessary to notice only two—the great maple, or mock-plane (*Acer pseudo-platanus*), and the American sugar-maple (*Acer saccharinum*)—the first on account of its timber, and the last on account of its sap.

The great maple, called also the sycamore, and the plane-tree, is hardy, stands the salt spray of the sea better than most trees, grows rapidly and to a great height. The timber is very close and compact, easily cut, and not liable either to splinter or warp. Sometimes it is of uniform colour, and sometimes it is very beautifully curled and mottled. In the latter state, as it takes a fine polish and bears varnishing well, it is much used for certain parts of musical instruments. Maple does not contain any of those hard particles which are injurious to tools, and is therefore employed for cutting-boards; and not being apt to warp, either with variations of heat or of moisture, it is an eligible material for saddle-trees, wooden dishes, founders' patterns, and many other articles of similar character. Before the general introduction of pottery ware, it was the common material for bowls and platters of all sorts, and some are even now made of it. As the juice of the maple, both in the leaves and in the tree, is sweet, it attracts numbers of insects. At certain seasons the wild bees and wasps may be seen about it in crowds; and if the timber be placed so that insects are allowed to settle upon it, the worm speedily attacks it. When kept dry and free from this evil, it will last a considerable time; but exposed to humidity it is one of the most perishable of trees.

THE OAK (*Quercus sessiliflora*).

SATIN-WOOD.

This beautiful wood, which has a light canary-yellow colour and satiny lustre, is imported chiefly from Nassau, in New Providence, one of the Bahama Islands. It comes in square logs about 10 feet in length, and about 8 inches square, and is used only for furniture and small fancy articles of cabinet-work.

AMBOYNA-WOOD

is also called Kyabuca or Kyabooca wood. There are several varieties of it to be found in our timber-yards; "they are probably all furnished (says Mr. Archer) by the same tree (*Pterospermum Indicum*)." It is most beautifully mottled and curled, of various tints, from light red to dark yellow, and always in small lumps, being evidently excrescences or wens cut from the trees. The varieties of Amboyna wood are principally used for inlaying, and by the makers of snuff-boxes.

BLACK EBONY.

This well-known black wood is very hard, heavy, and susceptible of a high polish. It is imported in sticks rarely more than 4 inches square, and 4 feet in length. About eighty tons are annually brought to this country. (Archer.)

CHERRY.

The wood of the cherry is very close, and in some sorts of a beautiful colour, and well adapted for the handles of tools. It takes a fine polish, and is not liable to split. Some of the bird-cherries are beautifully veined, and have an agreeable perfume, on which account they are much used by cabinet-makers, especially in the interior parts of the Continent. None of the cherries grow to be very large trees, but they may be frequently met with from a foot to 18 inches diameter at the root.

BEECH.

Like the chestnut, the beech thrives best in rich soils and sheltered situations, and when planted in suitable places, it is a beautiful as well as a valuable tree. The close texture of the beech renders it a very fit timber for machinery, for the stocks and handles of tools, and for many other purposes. It is not proof against the worm, however, and when exposed to alternate draught and moisture it soon decays. Against a cross-strain,

too, it is not so strong as the grained timbers. Although easily turned, it is not well adapted for large or hollow objects, as it is apt to split when drying.

(*) Only one species (*Fagus sylvatica*) is common to Europe. In England the Buckinghamshire and Sussex beech are esteemed the best.

Beech is stained to imitate rosewood and ebony, and is considered to be chemically free from foreign matters; for example, the glass-blowers use the wood almost exclusively in welding or fusing on the handles of glass jugs, which process fails when the smallest portion of sulphur, etc., is present. Oak is next in estimation for the purpose.

BIRCH.

This tree is a native of cold and inhospitable climates, and the dwarf birch is the last tree that is found as we approach the snow in elevated regions. Naturalists affirm that the birch-trees constitute the principal attraction to the birds which are found in such plenty in high northern latitudes.

(*) It is an excellent wood for the turner, being light-coloured, compact, and easily worked. It is in general softer and darker than beech, and unlike it in grain.

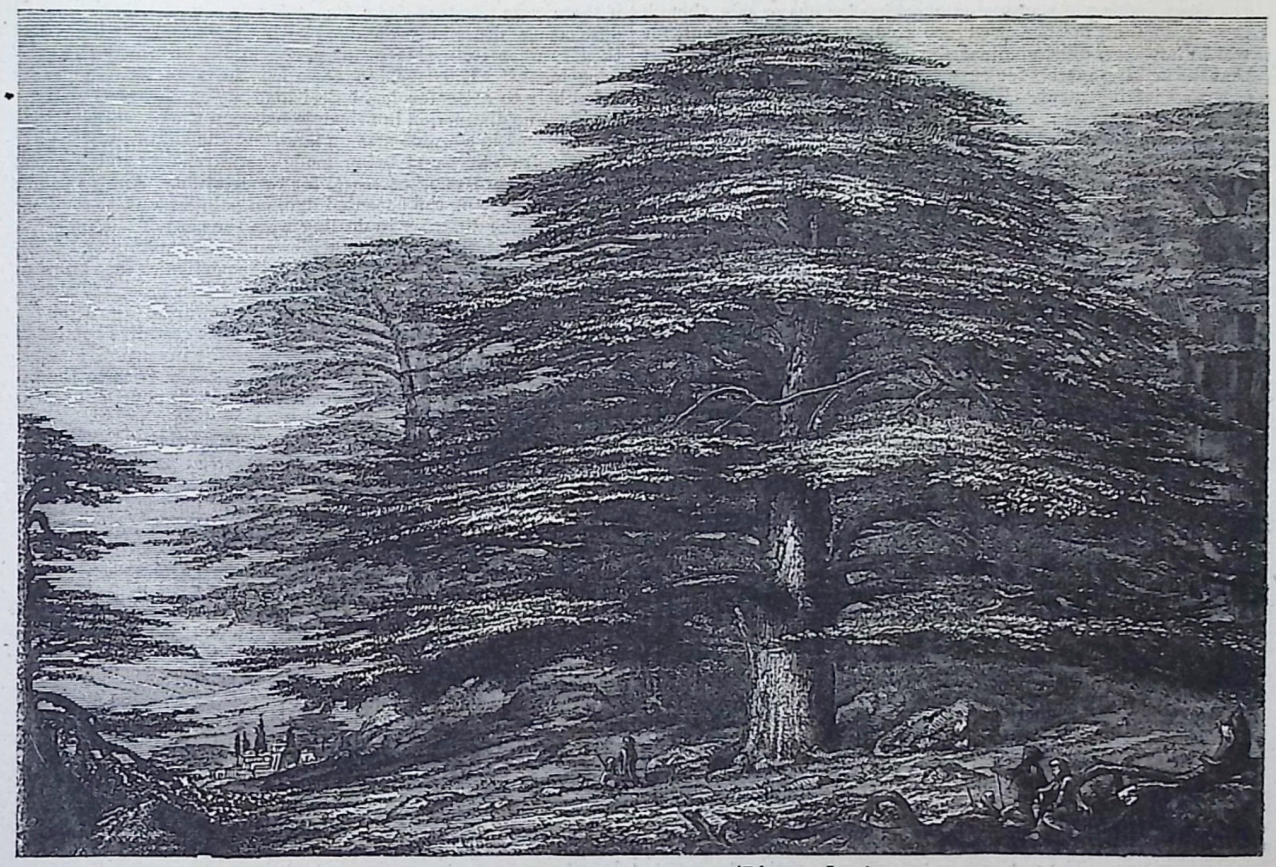
Birch-wood is not very durable; it is considerably used in furniture. Some of the wood is almost as handsomely figured as Honduras mahogany, and when coloured and varnished it is not easily distinguished from it.

The English birch is much smaller than the foreign, and lighter in colour; it is chiefly used for common turnery. Some of the Russian birch (called Russian maple) is very beautiful, and of a full yellow colour.

CEDAR.

(*) The name cedar has been given to trees of very different natural orders, and has occasioned much confusion. The cedar of Lebanon, or great cedar (*Pinus cedrus*), is a cone-bearing, resinous tree, and one of the pines. It is tall and majestic, and grows to a great size. The mean dimensions of its trunk are 50 feet high and 39 inches diameter. The wood is of a rich yellowish-brown, straight-grained, and has a peculiar odour. The tree is famous in Scripture for its size and durability. It was used in the construction of Solomon's Temple in Jerusalem, and many Grecian temples and statues. A few fine trees are said still to remain on Mount Lebanon, but the wood was also procured in the time of Vitruvius from other parts of Syria, and from Crete, Africa, etc. (Tredgold.)

The pencil cedar is the *Juniperus Virgineana*. It is also of the same nature as the pine-tree. It is imported from North America in pieces from 6 to 10 inches square. The grain of the wood is remarkably regular and soft, on which accounts principally it is used for the manufacture of pencils, and, from its agreeable scent, for the inside work of small cabinets. From the same reason it is made into matches for the drawing-room.



THE CEDAR OF LEBANON (*Pinus cedrus*).

The cedar known to cabinet-makers by the name of Havannah cedar is the wood of the *Cedrela odorata* of Linnæus, and belongs to the same natural order as mahogany, which it resembles, although it is softer and paler, without any variety of colour. It is imported in considerable quantity from the island of Cuba, and is excellent for the insides of drawers and wardrobes. All the cigar-boxes from Havannah are made of this kind of cedar. The wood is brittle and porous. Some kinds of the Havannah cedar are not proper for cabinet-work, as the gum oozes out and makes the surface of the work very sticky and unpleasant.

The limits of these papers preclude our giving a description of the other kinds of cedar, and of the "fancy woods" mentioned in our list. For the history of these the student is referred to other works devoted to this special branch of the subject. Much useful information may be found under the head of "Timber Plants and their Products," in a manual for elementary schools, published by Messrs. Cassell, Petter, and Galpin, and called "The Uses of Plants in Food, Arts, and Commerce."

PATENTS AND PATENT LAW.—V.

By A Barrister.

INFRINGEMENT.

The three obvious modes by which a patent may be infringed are these:—(1) By making the patented article; (2) by using the patented article; (3) by a sale of the patented article. We have used the term "patented article" in each instance, because it would appear that a sale of the *product* of the patented article would not be an infringement, unless the vendor is in any way connected with the use of the machine, when, apparently, it would be otherwise. So at least it has been decided. And it has also been held that the sale of the thing patented to an agent of the patentee is not, *per se*, an infringement, although it may be evidence of an infringement if accompanied by other circumstances. The American Judge Story decided also that the mere making of a patented machine for use or sale, though it were, in fact, neither used nor sold, is an infringement, for which, however, only nominal damages can be recovered, but that the making merely for experiment or philosophical purposes is not an infringement. This view was adopted by our English Judge Patteson.

The more important head is the second, namely, the user of the patented article. The American author Phillips, from whom we have already quoted, says that a use of the patented article is a direct and unquestionable infringement. The same writer makes some sensible observations on the distinction to be drawn between the contrivance and the actual production. "The art, contrivance, or design," he says, "considered abstractly, is not itself patentable, or an infringement of a patent. It is only in its production, in combination with materials, that it is either patentable itself, or a violation of a patent right. In a patented instrument or piece of machinery the subject of the patent exists, and is visible and tangible, and admits of being possessed and delivered distinctly and independently of its products. But when a composition of matter is the thing patented, the subject of the patent is identified with its products, or rather a specimen of the product, or the only vendible thing which it is the object of the invention to supply, is at the same time a specimen of the invention itself; whereas, in the case of an instrument or machine, one object of the invention is to produce the instrument or machine itself, another to produce its products. The inventor of a loom may propose a profit on the sale of it, as well as on the sale of its product. So again, a steam-engine, like a loom, is invented to be used as an instrument until it is worn out; and in this respect, both differ from a patent medicine or many chemical compositions which are consumed and destroyed at once in the use." He contends that the use of a patented article which is consumed in the use, and of one which lasts a long time, is equally an infringement. Thereupon he proceeds to inquire what is the use, and who may be said to use the article? In the case of a patented paint, can the lessee who occupies a house painted with the patented article be said to use it? or can the lessee or purchaser of a chaise varnished with patented varnish be said to use the varnish? In either case he answers in the negative. The person who selects and applies the article is the person who uses it. So the doctor or the apothecary, not the patient, uses the patent medicine; but where the article is durable it is otherwise, as the cultivator uses a plough, and a manufacturer a loom, and so they, no less than the vendor, infringe the patent right.

We may usefully accept from the hands of the learned author some principles established in the summary of American cases which he gives. First, then, the person who uses an article to which a patented improvement is attached, uses the improvement so as to infringe the patent. A mere contract to purchase the articles produced by the instrument is not a constructive use of it by the purchaser. And as already suggested, a use of the patented article merely for philosophical experiment, or for the purpose of ascertaining "the merit and exactness of the specification," is not an infringement. That a patent cannot be infringed by anything done before it is granted, is a self-evident proposition.

The above is American law, but it coincides with our own. To show that this is so, we will refer to the famous case which we have already consulted for other purposes, the case of Betts's patent for capsules for bottled beer, which will well illustrate what is meant by the use of a patented article amounting to an infringement. There the point was, whether there was an infringement in England to which only the letters patent extended. It was proved that the beer was bottled in Scotland, and then sent through England to places abroad. It was insisted that this was no infringement of the patent in England; that the sale of the capsuled bottled beer took place in Scotland; that it was merely *in itinere* in England; that in its resting-place with the English agents there was no active *use* of the patented article which could constitute an infringement. The Lord Chancellor (Chelmsford) said, "A variety of cases were supposed in argument to show to what extravagant consequences a decision against the defendants would lead. It was asked whether if the beer was sent by sea, and arrived at an English port, and was there transhipped for exportation without being landed, there would be an user of the capsules in England; or whether, if there were a patent for a particular dye, and a lady were to purchase a dress in Paris dyed with the patented colour, and then to wear it in this country, she would be guilty of an infringement." His lordship regarded these as extreme cases not likely to arise for legal decision, but he observed that he could see no distinction in principle between the patented article being placed in a warehouse on land, and the ship in which it is brought from Scotland being made the warehouse until it can be put on board another vessel for exportation. And as to the suggested case of the patented dye, he pointed out that there might be some difficulty in dealing with the case of the ignorant use of a patented invention under such circumstances. Lord Chelmsford then proceeds to deal with the particular case on principle. He remarked:—"The infringement of a patent is a tort, and all persons who are in any way acting towards it are jointly answerable. If, then, the mere presence of the capsuled bottles in England amounts to an user of the plaintiff's invention, Messrs. Tennant, who send the beer into England, are parties to the infringement, whether they derive profit from this course of transmission or not. . . . I do not appreciate the distinction which was pressed upon me in argument between an active and a passive use of a thing." He referred to a case of an alleged infringement of a screw-propeller, and said, "This screw-propeller in the one case, though in motion during its use, was just as passive an agent as the capsules in the present case. *It is the employment of the machine or the article for the purposes for which it was designed by the persons so employing it that constitutes its active use.* Whether the capsules were intended for ornament, or for protection of the contents of the bottles upon which they were placed, the whole time they were in England they may be correctly said to be in active use for the very objects for which they were placed upon the bottles by the vendors. If the beer, after being purchased in Glasgow, had been sent into England, and had afterwards been sold here, there can be no doubt, I suppose, that there would have been an infringement, because it would have been a profitable user of the invention. I cannot see how it can cease to be an user, because England is not the final destination of the beer, if the capsules while they are in this country are upon the bottles, doing their duty (whatever that may be), for which they were placed upon them."

It is scarcely necessary to point out the important principles established by this judgment; but for those who do not follow the judgment, we may state that there may be an infringement by the active though unprofitable use of the patented article, and that active use simply means the employment of the article in the ordinary manner designed by the inventor, and that the mere presence of the patented article in the geographical limits to which the letters patent extend in such use is an infringement. In this case, in the Court of the Lords Justices of Appeal, one of the learned judges said that he could see no distinction between the active and the passive use of a patented article.

In a somewhat similar case at common law, in which some remarks were incidentally made on the interesting question of an infringement by a person ignorant of the existence of the patent, the subject generally was discussed by the judges of the Court of Common Pleas. The facts in this case were that the articles alleged to be an infringement of the English patent were imported from abroad, having been manufactured in a foreign country. We are brought by this case to the consideration of infringement by sale. Chief-Justice Erle, in the course of his

judgment, said, "I have heard the arguments of the learned counsel on both sides derived from the original statute which uses the words 'work and make,' and the form of the expression about working, making, or putting in practice, and the introduction of the words 'vending,' 'make, use, exercise, or vend.' . . . It appears to me to have been clearly the intention in the grant of the privilege to prohibit a party vending the patented article for the purpose of profit by the selling. It is the main purpose of the patent to give the profit to the patentee, and the main mode of defeating that would be by selling a patented article; and it does seem, without proof of the making of the article by the infringer, if he sold the patented article for profit, it may be good evidence upon which a jury may find that he had infringed the patent." Then as to the question of the defendant not being liable for the sale of articles because they were imported from abroad, his lordship added, "I should say that, even if it was a simple case of importation without any proof of knowledge that it was a patented article, or knowledge of the infringement, that would be sufficient evidence of infringement to charge the party with infringing, if he had imported or sold."

This question of ignorance is important, as it may appear hard that an innocent person should suffer the penalties of infringement. It has, however, been distinctly laid down that a use of one process in ignorance that it is capable of being accurately represented as an imitation of an earlier invention is an infringement. This is illustrated by a very recent case with reference to a patent for plaited frills or trimmings. Wilcox had taken out a patent, and Orr adopted a process which, unknown to the defendants, was an infringement of Wilcox's patent. They were yet held guilty of an infringement by buying and selling the goods made by Orr's process. This point as to selling is very important, and is distinctly dealt with by Lord Chief Baron Kelly, who said, "The statute does not certainly contain the word 'vend,' which is found in the grants of patents, but we may have some regard to the constant usage according to which for 200 years patents have contained an express licence to use and vend; and although the use of this word by the Crown is not conclusive upon the construction of the statute, it would be strange that for so long a time every patent should have purported to confer the exclusive right and interest if the grant were unauthorised. . . . It may be that in most, if not all of the cases when narrowly examined, it appears that the defendants had some part in the manufacturing as well as in the selling of the article. But if it is now necessary to decide the point, I am clearly of opinion that if a man takes out a patent by means of which an article is made at a considerably less cost than the same article was before produced at, one who buys and sells such articles—I do not say on a single occasion, for each case must be determined on its own circumstances, but when he becomes in the way of trade a buyer and seller of quantities of such articles—knowing them to be manufactured by a machine which is, *de facto*, though unknown to him, itself an infringement, such buying and selling is an infringement by him of the patent. . . . It is impossible to suppose that an exclusive right to vend is not given, and the defendants have therefore infringed the plaintiff's right, *and it is immaterial whether it was or was not known to them that Orr's machine was identical with the plaintiff's.*"

There being no doubt about a case of actual sale, there might be a doubt where the article is manufactured and offered for sale, but no sale is effected. It is said to have been laid down, although this does not clearly appear to be the case, that this would amount to an infringement. On the principle, however, that where the intending vendor is connected with the use of the machine, the sale is an infringement, it would seem to be good law. On the other hand, it has been expressly decided that merely "exhibiting to sale" imitations of an invention is not any infringement of the patent.

We will now proceed to consider the case of the infringement of a portion of a patent, that is to say, the use of a part of a combination. To begin with, let us state the effect of three leading decisions. An infringement of any part of a patent process is actionable, if that part is of itself new and useful, so as that it might be the subject-matter of a patent, and is used by the infringer to effect the object proposed either wholly or partially by the patentee. A patent for an entire combination is not infringed by a different combination, for the same object, of the same elements, though important, or of equivalents for them, if not a mere colourable evasion or imitation. If a patent is taken out for an invention by means of a combination, the use of a subordinate part of the combination is no infringement of the patent, unless such part is new and material. Then as regards the exportation of parts of a patented machine, the rule has been laid down, that though the manufacture in this country of the several parts of a patented machine, and the exportation of those parts may not be an infringement of the patent, the machine being the novelty and the parts being old, it is otherwise where the part exported is itself the patented invention. The general principle as to the infringement of parts is, that where a patent is for an invention consisting of several parts, the imitation of any part of the invention is an infringement of the patent.

This being a point of some nicety, we will give an illustration. The specification of a patent for improvements in wheels described the invention as consisting of a mode of forming a wheel of one solid piece of wrought iron, by means of welding pieces of wrought iron together, so as to form the iron spoke and nave into one compact mass. The defendants in the case used a wheel made by welding pieces of wrought iron together so as to form a single compact piece of wrought iron; the mode of forming the nave was the same as that in the specification; the mode of forming the rim was different. It was decided that as it appeared that the mode of forming the nave was a material, new, and useful part of the invention, the use of it by the defendants was an infringement of the patent, although in the specification, after describing the whole structure, the invention was stated to consist in the circumstance of the centre boss or nave, arms and rim of the wheel, being wholly composed of wrought iron welded into one solid mass "in manner hereinbefore described." The judge at the trial of the case intimated his opinion that the claim was for the invention of a wheel as described in the specification; but that if the defendant had imitated or pirated the mode of welding the nave, and that were a material part of the invention, there was an infringement of part of the patent, for which the action was maintainable. The full court concurred in this view, and go on to say, "Where a patent is for a combination of two, three, or more old inventions, a user of any of them would not be an infringement of the patent; but where there is an invention consisting of several parts, the imitation or pirating of any part of the invention is an infringement of the patent. Suppose that a man invents a machine consisting of three parts, of which one is a very useful invention, and the two others are found to be of less practical use, surely it could not be said that it was free to any person to use the useful part so long as he took care to substitute some other mode of carrying out the *less useful parts* of the invention."

The leading case on this subject was heard in 1866 before the House of Lords, and had reference to "improvements in certain machines for spinning and doubling cotton and other fibrous substances of the kind commonly known as mules and twiners." The plaintiff there contended that the defendant had infringed the patent of his machine. It was there recognised that the ordinary courts are not suitable for the trial of patent cases. The Lord Chancellor said, "It is extremely difficult in questions of this description for an unscientific person to arrive at a satisfactory conclusion, as he is sure to be perplexed with the contradictory opinions which the skilled witnesses on both sides invariably oppose to each other." The important point was that the two machines brought out different results, and the same learned lord said, "Upon a question of combination, the action of two machines with differently disposed parts, *differing so materially from each other in their different effects*, almost necessarily leads to the conclusion that there must be a substantial difference between them." The argument in support of the infringement was that whatever the effect was, the means by which it was attained in each case were substantially the same. In spite, however, of the resemblances, three courts decided against the alleged infringement. Any one who desires to see what a fight between two patentees means should look at the report of this case of Curtis *v.* Platt reported before the House of Lords in 35 Law Journal Reports, Chancery, at page 852.

It is not our province in these papers to give an exhaustive reference to every species of infringement to be found in the

decided cases, and we believe we have done sufficient to show with tolerable completeness what under different conditions may and what may not amount to an infringement. We will now simply refer to the place where an infringement may take place. It has already been shown by reference to the case of the capsules for bottled beer, that the mere fact of being on board ship in English waters for the purpose of transhipment may be an infringement of an English patent. To take a case on the other side of the question. Mr. Newall obtained a patent for "improvements in apparatus employed in laying down submarine electric telegraph wires," and by his specification and drawing annexed gave a full description of the manner in which it was to be performed. The patent was limited to the United Kingdom, the Channel Islands, and the Isle of Man. The infringements of which Newall complained occurred on board ships which had been prepared by the defendants for the purpose of laying down a submarine electric telegraph cable between Rangoon and Singapore. Ultimately the cable was laid between Malta and Alexandria. The court found that nothing had been done in England amounting to an infringement, and counsel did not argue upon what had been done at Malta. But Baron Bramwell addressed himself to this point. "I am clearly of opinion," he said, "without going into any elaborate consideration of how far a vessel of a country is the territory of a country, the doctrine cannot be carried so far as to make anything done abroad an infringement of letters patent, which are in their terms limited to the United Kingdom, the Channel Islands, and the Isle of Man."

Before proceeding to notice the means of obtaining redress for an infringement of a patent—in other words, to inform our readers of the nature of a patent suit—we may briefly state what is the measure of damages to be awarded, so that a patentee may know what to expect before commencing proceedings. He may, of course, obtain an injunction. He may also obtain a decree for damages. A good deal depends upon the circumstances of the case, but it has been recently decided that a patentee of an invention who, himself a manufacturer, has been in the habit of licensing the use of his invention by other manufacturers on payment of a fixed royalty for each machine, having obtained a decree for damages "by reason of the using or vending" of the invention, is not entitled to claim by way of damages any sum beyond the ordinary royalty. Hence he is not entitled to claim, in addition to his ordinary royalty, a manufacturing profit; and, *à fortiori*, not such a manufacturing profit as he would have made if every unlicensed machine had been sent to him to be fitted with the invention. From this example an opinion may be formed as to the probable result where the circumstances are different.

CIVIL ENGINEERING.—XXI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

PILES AND PILE-DRIVING.

The value and importance of piles in the consolidation of an insufficiently compact soil which it is intended to make the foundation of a structure, and their absolute necessity in forming the foundation of almost every kind of marine engineering work, except, indeed, when the solid rock becomes itself the foundation, renders a careful consideration of the subject not only desirable but necessary, and we cannot do better than take it up at the present period, and before introducing the important subject of bridges, whose stability is so greatly dependent upon the character of their foundation.

In the course of our remarks upon docks it will have been observed that reference was frequently made to two classes of piles—those placed *beneath* the walls, and those standing in *front* of them. The former are the main-piles, the latter the sheeting-piles. The main piles are driven into the super-soils until their lower extremity reaches the more solid stratum. When it may be necessary to cease to drive a pile is a point which must be left to the discretion of the engineer.

No engineer would commence a work of any magnitude without first satisfying himself, by boring, of the nature and depth of the various strata beneath the proposed structure, and upon the result of these borings he will base his arrangements for piling. A few words respecting the piles themselves. The size and quality of piles will depend upon the soil and the work they have to do. If of timber, they are either of oak, elm, beech, or fir; if the last named, either Dantzic, Memel, or red American. They should be perfectly sound, formed of the straightest timber, the fibres being in no way twisted, and of an even scantling throughout. They are pointed at the lower extremity and shod with wrought-iron shoes, and to prevent their splitting under the blows of the ram they should have strong iron hoops encompassing their upper end.

It is essential to bear in mind that timber piles, although capable of remaining in a sound condition for ages under the simple action of water, are nevertheless in many situations liable to rapid destruction from the attacks of the *Teredo navalis*, a worm which is able to bore into fir timber with incredible rapidity, and which has caused in more than one instance the entire destruction of an arch supported wholly on timber struts. The action of this worm is always greatest when the water is salt or brackish. The size or scantling of piles will vary somewhat with their length; if of oak, their diameter is usually about the twentieth part of their length. The distance apart at which piles should be driven is an important matter. The use of a pile is twofold, for not only does it transmit the solidity of the sub-soil upon which it rests to the superstructure, but compresses, and therefore consolidates, the soil around it. The closer piles are driven together the greater is the compression of the soil, because, being displaced by the timber, it is necessarily forced away laterally. For this reason it is always advisable in driving the piles for a heavy superstructure, such as the pier or abutment of a bridge, and in any case where it is intended to place the piles near together, to commence with the central row, and to work outwards from these, first upon one side and then upon the other, so as gradually and evenly to force away the soil, and thus to render it very firm on all sides of the intended structure.

In driving piles deep it is natural to expect that the deeper they descend into the soil the greater will be the force needed to drive them. This results not only from the increasing density of the sub-soil, supposing it not to vary in the character of the strata, but also from the increased friction upon the sides of the timber. It is important, however, to bear in mind that extreme force being required in driving a pile is not to be regarded as a certain proof of a firm bottom having been reached. In clay, for instance, the pile sometimes becomes a conductor of water, which finds its way along the sides, softening the clay and rendering it greasy, and gradually permitting the pile to settle deeper, and, indeed, rendering the piled foundation less secure than the natural clay base would have been. In such a case certain unyielding nuclei should be established by piles driven a few feet apart, the intervals being subsequently filled in with other piles driven as closely together as possible. The depth at which a pile should be driven is a point, we have said, to be decided upon by the engineer after careful consideration of all the circumstances of soil and subsequent weight to be borne. Piles, well driven into good holding ground, will, if placed about 4 feet apart from centre to centre, sustain the weight of any pier. A single pile of 12 inches diameter will, if well driven in good soil, bear with safety a load not exceeding 50 tons, and one of 9 inches diameter a load of 25 tons.

It may sometimes be desirable to incline the direction of the outer piles of a foundation with their bases outwards, by which arrangement a very efficient support is given to the interior piles, and any tendency they may possess to swerve from the perpendicular under the weight of the superstructure is prevented.

The heads of piles for bridge-work should be cut off near the surface of the ground, level and even, and the soil be removed from between them, if not driven closely together, to a depth of 9 inches or a foot, and the space filled in with concrete to the level of the heads. This will generally be found to form the best basement for the masonry of the building.

Sheet-piling varies from 4 to 6 inches in thickness, and about 12 inches in width. When they are intended for the facing of a wall it is seldom necessary to drive them as deep into the soil as the main piles; the necessity or otherwise of shoeing them with iron must depend upon the soil. They may require to unite closely with each other at their sides, and in such cases there is a groove formed in the side of each to receive a plank.

The machinery employed for driving a pile is an important

feature in engineering. The length of time consumed in driving piles is very considerable, and it is desirable to accelerate the process by every available means. The progress of invention in this respect has been gradual. All pile-driving engines are based upon the principle of percussion, a weight more or less heavy being raised vertically over the head of the pile, and allowed to fall upon it through a greater or less space. When the piles to be driven are short, and the ground comparatively yielding, a heavy wooden *beetle* or maul is employed. It is simply a block of hard wood hooped with iron, and furnished with one or more handles radiating sufficiently from the centre to enable each handle to be grasped by a man, the united action of several being thus available for raising a heavy weight and imparting a powerful blow. But such an arrangement is entirely useless when much pile-driving has to be accomplished, and the piles are of a large size.

The pile-driving engine is of two kinds: that worked by manual or horse-power, and that in which steam is employed as the motive power. A manual pile-driver consists of a block of iron termed a "monkey," furnished with studs or projections to fit into grooves in the timber framing, in which it works vertically, and by which it is guided in its course. The size of the monkey varies from 2 to 12 cwt., or even more according to the work to be done. If small, it is raised by a single rope passing over a pulley at the top of the frame, and finally divided into several ends, at each of which a man is stationed, and by whose united effort the weight is raised and allowed to fall. When the monkey is large it is set in a framework of wood standing vertically upon a base formed of several timbers framed and bolted to the uprights at right angles, and to which is securely attached a crab. A strong pulley is placed at the upper end of the vertical timbers over which passes the chain by which the monkey is raised. The longer end of the chain passes round the cylinder of the crab, which is furnished with two handles worked by several men. An inclined ladder, fixed in the diagonal of the framework, affords access to the pulley and upper parts of the machine. The guides in which the monkey works are plated with iron to resist the wear and tear due to the repeated passage of the block. Nippers, similar to those shown in Fig. 48, are attached to the free end of the chain, and serve to connect the chain to the ring of the monkey. When the monkey has been raised to a sufficient height the upper arms of the nippers are contracted by entering a wedge-shaped opening, and the lower jaws opened, thus releasing the monkey, which falls by gravity through the space intervening between its maximum height and the top of the pile. Immediately the monkey is released, the pawls of the crab are released, and the nippers and chain descend by their own weight, and the lower sides of the jaws of the nippers being bevelled, open as they touch the ring of the crab, and close when they have embraced it, so that the duties of the men are confined to the simple work of raising the monkey and letting the chain follow it after it has fallen. As the pile continues to sink into the soil the distance between it and the raised monkey increases, and the blow delivered is therefore heavier. But the time occupied in raising the weight is increased, although not in proportion to the advantage gained, since the velocity of the falling weight is as the square root of the height, whereas the time occupied in raising it is directly as the height only. It will be useful to insert a table showing the value of the blow of a ram falling through various heights. As the ram may be supposed to fall 16½ feet in a second, according to the laws of gravity in this latitude, it is easy to calculate its velocity in falling through any given height, assuming it to be proportionate directly to the time of its descent. The velocity acquired at the end of the first second is equal to 32⅔ feet in a second, at which speed it enters upon the fall through the third second, and so on. It is, therefore, only necessary to multiply the force in the column of *force*, in the subjoined table, by the weight of the ram, and the force of the blow is immediately ascertained.

Fig. 48.

For instance, if the ram weigh only 1 *cwt.*, its force in falling through 1 foot = 8 cwt.; if the ram weigh 8 cwt., its force will be 8 × 8 = 64 cwt.; and if it weigh 10 cwt., and fall through 10 feet, its force will be 10 × 25·3 = 253 cwt. The student can easily make further calculations for himself, under different conditions given in the table.

Fall of the ram in feet.	Time of the descent in seconds.	Force in tons of a ram weighing 1 ton.	Fall of the ram in feet.	Time of the descent in seconds.	Force in tons of a ram weighing 1 ton.
1	·25	8·0	21	1·14	36·7
2	·35	11·3	22	1·17	37·6
3	·43	13·9	23	1·20	38·5
4	·50	16·0	24	1·22	39·3
5	·56	17·6	25	1·25	40·1
6	·61	19·6	26	1·27	40·9
7	·66	21·2	27	1·29	41·7
8	·70	22·7	28	1·32	42·4
9	·75	24·1	29	1·34	43·2
10	·79	25·3	30	1·37	43·9
11	·83	26·6	31	1·39	44·6
12	·86	27·8	32	1·41	45·4
13	·90	28·9	33	1·43	46·1
14	·93	30·0	34	1·45	46·8
15	·96	31·0	35	1·48	47·4
16	1·00	32·1	36	1·50	48·1
17	1·03	33·1	37	1·52	48·8
18	1·05	34·0	38	1·54	49·4
19	1·09	35·0	39	1·56	50·1
20	1·11	35·9	40	1·58	50·7

In the arrangement of nippers already alluded to it is necessary that they shall always rise to the height of the contraction before they release hold of the ram. This may not always be convenient, especially when the pile has descended very low. To obviate this defect a hook fitted with a long tail-piece, to which is attached a rope, is sometimes made use of. The hook works laterally on a pivot in connection with the chain, and being heavy, falls naturally into the ring of the ram until withdrawn by a strain being put upon the rope attached to the tail-piece. By this method the ram can be made to descend at any moment required.

The steam pile-driver is a great improvement upon that worked by manual labour. It is in principle precisely similar to a steam-hammer. The steam-cylinder is inverted, and the ram fixed to the head of the piston-rod, which passes out of the lower end of the cylinder. The admission of steam upon the lower side of the piston raises both it and the ram, and the escape-valves being opened simultaneously with the closing of the steam-valve, the ram falls by gravity through the entire height of the cylinder. Its force may be supplemented, if necessary, by the admission of steam above the piston. The power and rapidity of these blows are very great.

Piles are employed in many other situations besides forming the foundation for piers, etc. In those positions they naturally remain; but in many cases, as, for instance, coffer-dams, their use is temporary, and after being no longer required, they have to be withdrawn in order to free the navigation. Sometimes their withdrawal is attended with considerable trouble. Not only is there the friction of the soil to overcome, but the weight of the pile, and the suction of the water, added to the oxidisation of the iron shoe. So considerably, in fact, does the latter cause affect the withdrawal of the pile that in sea-water, where oxidisation is most likely to occur, the iron shoe may with advantage be sometimes omitted. The operation of withdrawal may be greatly assisted by striking the heads of the piles obliquely; indeed, an upward blow given with some heavy body will occasionally have greater effect in moving a pile from its bed than any amount of dead leverage. If the head of the pile is above the water, a strong bolt may be passed through it at a sufficient distance below its top to ensure that no movement of the fibre or splitting of the pile results. To this bolt will be attached the chain for withdrawing the pile. If the head is below water, or in some position where it is impracticable to pass a bolt through it, a strong square iron collar, somewhat larger than the pile, is passed over it, to one side of which the withdrawing chain is attached. The pull is thus given obliquely, and the edges of the collar bedding themselves into the wood prevent its slipping. A screw working in a strong framing, through the head of which capstan-bars are passed, forms a powerful means of withdrawing a pile. A very ordinary method

of accomplishing this in tidal waters is to attach the withdrawing chain to a strong bowsprit projecting over the extremity of a barge, the chain being made taut at low water. As the tide rises the pile will be withdrawn to the extent nearly of the rise of the tide.

When it is intended that piles shall remain as a permanent portion of a foundation it will be necessary to cut their heads off to a given level. Of course, if the foundation be dry, the operation is simple, but when under water a machine of a peculiar construction is necessary. The machine employed at the bridge of Choisy consisted of a horizontal frame, to the centre of which were fixed two upright bars. The saw-blade, which cuts horizontally, was fixed to the lower extremities of the uprights, to the upper ends of which the tightening-bar was attached. The frame was worked backwards and forwards by men, whilst by means of a rope fixed to the lower ends of the uprights another workman applied pressure of the saw against the pile. By means of this machine a pile from 10 to 12 inches square was sawn off in twenty-five minutes by a carpenter and six labourers, the saw-cut being 3 feet 8 inches below the horizontal frame. Machines of a more complex character become necessary when the depth of the saw-cut below the surface of the water is considerable.

ENGLISH CARRIAGE-BUILDING.—II.

BY A LONDON COACH-BUILDER.

AXLES—SIZE AND POSITION OF WHEELS—SPRINGS—FORE-CARRIAGE—FUTCHELLS.

Having thus arranged the size and shape of the body, we can decide the length of the axles, the size and position of the wheels, the length and span of the springs, and all the details of the fore-carriage. We want the wheels to be 3 feet 8 inches behind, and 3 feet 2 inches in front. If we refer to Fig. 1, showing the drawing of the brougham on the canvas (page 129), we shall see that we have 2 feet 7 inches to spare between the ground-level and the under part of the pump-handle. Half the height of the wheel will be 1 foot 10 inches; this gives us the position of the hind axle, and, allowing for the thickness of the axle, leaves us barely 8½ inches for the thickness and span of the springs, together with the thickness of block, top and bottom of the spring. This is not sufficient, and shows us where our drawing is faulty, or rather, not properly placed; for a wheel 3 feet 8 inches high, we must therefore give more curve to the pump-handle, by which means we may gain as much extra space as we require without altering the height of our wheels, or without raising the body higher from its present ground-level.

Then, by measuring the height in front, from the ground-level to the bottom of the boot, we shall find we have 3 feet 5 inches to spare. Half the height of the front wheel will be 19 inches, which will leave 10 inches for the span and thickness of springs, half an inch of block top and bottom of springs, and 11 inches for the depth of the fore-carriage, top and bottom, including the bracket blocks.

We must next decide the length of the axletrees. As a general rule, it may be taken for granted that the inside width across the body at the top of the door-rail should be the length of the hind axle, from collar to collar over all. Thus, should the width across the body at this point be 3 feet 8 inches, the length of the axle between the points indicated should be 3 feet 8 inches; the side cant of the body and the turn-under of the standing pillar, together with the set-under of the axletree and the dish of the wheel, will carry the wheel sufficiently out from the side of the body without allowing anything more.

The front axle should be half an inch longer than the hind one, for the wheels to track, because the dish of the front wheel—this wheel being lower than the hind one—will not throw the wheel out on the ground-level so far as the hind. The distance of the hind axle-flaps from collars will be regulated by the width of the body across at the hind bottom sides, where the pump-handles are fixed, and that of the front axle-flaps by the width across at the bottom of the boot.

The next thing is to strike the position of the wheels. The hind ones must be thrown sufficiently far back to allow the door to open freely without touching the wheels, and if the door be hung with concealed hinges, the thickness of the door must be taken into consideration, as the concealed hinges bring the inside of the door flush with the standing pillar when open to the full extent.

To decide the position of the front wheel is not quite so simple. As this has to lock or turn under the arch, the play of the springs, and the length of the axletree, the height of the arch, and the relative height of the wheels, all have to be taken into consideration.

The centre on which the two front wheels revolve as they lock round is the perch-bolt, and the size of the circle they describe is therefore determined by the length from that centre to the tire of the wheel; but while that part of the wheel which comes in contact with the ground is describing one circle on the ground, the back part of the wheel is describing a more extended circle in space. This Fig. 4 will show.

The horizontal line A is the axletree, B is the wheel at rest, C is the wheel on full lock, D is the back of the arch, E is a section of the ground circle the wheel will describe as it moves backward, and F is a section of the circle the back of the wheel will describe in space during the same movement. It will be seen by this, that when the wheel is on half-lock, the back part of it will come in contact with the arch, and that when on full lock it will have travelled right away from it. It follows, therefore, that if we want to find out the right position for the perch-bolt to occupy, we must not measure the circle the wheel will describe on the ground, but the one it will describe in space. We must, therefore, measure along the line F, and carry that measurement up to D.

The diagram here given is to half-inch scale, and the length of the line from A to D is exactly three feet. Now the position of the perch-bolt, or centre-point on which the wheels lock round, need not be, and, as a matter of fact, rarely is, in a line with the axletree. By compassing the beds or timbers on which the fore-part of the body rests, and through which the perch-bolt passes, the centre of the circle described by the lock may be carried forward. Thus, if the beds be compassed four inches forward from the straight line along the axle, the centre will be carried forward four inches, the result of which will be, that when on the half-lock the back part of the wheel will be carried away from the arch two inches, and that when on the full lock the wheel will stand four inches back from the position it would occupy if the bed was straight. The dotted lines below F and E on the diagram will show the result of this difference in the shape of the bed, and it will be seen that in order to get a two-inch clearance of the arch from the back of the wheel without carrying the wheel itself farther forward than three feet from the back of the arch, we must compass the bed four inches, the compass-mark being to the centre of the substance of the bed.

Having arranged all these particulars, we can strike the position of the wheels, we can give their height and dish, the length of axles, with the position of flaps, and the length of arms. We can give the span and the length of the springs, and all the necessary details for the construction of the body in every particular; we have only to make our patterns of the different parts, and prepare our sweeps to enable us to proceed with the whole business of building.

Before a workman could be trusted with the making of a body he must, of course, have considerably advanced in the knowledge of his craft beyond the mere knowledge of the use of his tools. It will not be necessary, therefore, for his benefit, to describe in detail all the different parts that form the framework of the body, nor would such minute detail be interesting to the general reader. It will be sufficient to say, that in marking out the stuff, care should be taken to lay the patterns on the timber, so that the grain run as near as possible in a line with it: thus, if the pattern be straight, the grain of the timber should be straight; if the pattern sweep round, the grain should run with the sweep. Again, some mild or light description of timber should be selected for the door-pillars, and some hard strong timber for the hind bottom sides, where the pump-handles are fixed, as well as for the front-boot bottom sides.

If the foreman who superintends all this be accomplished in his department, and if the workmen on his staff be equally skilful in theirs, the work may be distributed among almost as many men as there are parts in the framework of the body; these parts will be worked up, the mortises and tenons, the rabbets and tongues cut to a specified gauge; and when they are all ready, they will go together like a Chinese puzzle, or a pack of cards.

In the construction of the body the smith plays an important part, and we require some of his best workmanship. All along each bottom side of the body should be plated with iron; this should be of the toughest quality, and the best brand. The edge-plate, as this is technically called, may be regarded as the back-bone of the body. It should run from one extremity to the other, commencing at the hind bottom bar, on to which it should be cranked, and ending at the front part of the front-boot bottom side. This plate should take a perfectly flat bearing at every point. Great care must therefore be taken in fitting it, for although the plate may be of the requisite strength, the absence of this perfect fitting will render it comparatively weak, the result of which will be found when the body is finished and mounted on the wheels, by the springing of the sides, which will cause the pillars of the body to press on the doors.

When the body is finished from the hands of the woodman, it passes into the hands of the currier: a hide of leather is specially prepared for it, and in a soft pulpy state is strained over the roof, the back, and the top quarters of the body, and sleeked down till the surface is perfectly smooth at every point. It is then nailed down and left to dry, which will take several days, after which it passes into the hands of the painter; meanwhile the carriage-work, the wheels, the axles, and the springs, have all been got ready, and the body mounted.

The axles should be made of the best scrap iron fagoted, that is, a number of thin rods of iron should be taken like a bundle of fagots, and twisted and welded together into a solid mass; whether they are so or not may be detected by putting them into the fire, and heated to a red heat. If fagoted, the marks of the different rods running like grain in wood will then be plainly seen; if not, the heated part of the axle will present a perfectly clear and grainless appearance. The advantage of fagoting is the greater amount of strength thus given to the axle; the flaps, which support the springs, should be in the solid, and the axle-arms should be made on Collinge's principle, as no better has yet appeared in the market. The springs should be made of the best spring steel, specially prepared for the purpose by the best makers, and the wheels should be made of good tough elm for the stocks, cleft sapling oak for the spokes, and sound English ash for the felloes.

The carriage part of a vehicle, as distinguished from the body, comprises all that part or those parts on which the body is placed; the term may be said more particularly to apply to what is technically called the fore-carriage, which consists of the top carriage, which is bolted on to the bottom of the flat part of the boot, and the bottom carriage, which carries the front wheels, and is connected with the top carriage by means of the perch-bolt. The timbers of these are named the beds, which we have already indicated as those through which the perch-bolt passes; the horn-bar, which stands at the back of the top bed; and the futchells, which are either opened or closed—the open futchells being those which are made of bent ash, and stand wide apart to carry the shafts when the carriage is to be drawn by one horse only; and the close futchells are those which are made of sawn timber, and brought together to carry the pole when the vehicle is to be drawn by two horses. These different descriptions of under carriages are fitted respectively to what are termed single or pair horse carriages.

All these timbers should be made of sound strong ash, and well plated with iron: indeed, modern taste largely exacts the substitution of iron for timber in this part of a pleasure carriage; and here it is that the skill and taste of the smith are particularly displayed, not only in the fitting and finishing his plates, but in the formation of all that iron-work which connects the different parts of the carriage and springs with each other.

We give in Figs. 5 and 6 designs of two different descriptions of fore-carriages, in order that what we have to say in connection with this department may be more clearly understood. The central circle is the wheel-plate, or, as our American cousins call it, the fifth wheel; this is flat at the bottom and round on the top, and, being fixed to the under part of the top carriage, takes its bearings on the bottom carriage, and by its extended circular formation gives steadiness to the body when the vehicle is running in a straight line, or when the fore-carriage is on full lock. These bearings are at the back ends and the fore part of the futchells, and at those points of the bottom bed which are covered by the wheel-plate. The fore and hind bearings are of ash timber, and are necessarily circular in form.

It will be seen how imperative is the necessity of the wheel-plate being a perfectly true circle, and of taking a perfectly flat bearing; the forging and finishing such a piece of workmanship requires, therefore, peculiar care and skill. In the diagram showing the open futchells, the stays which run from the back end to the front of the futchells are the wheel-irons, the back-stays, and the bed-clips in one. They clip over the ends of the bottom bed, and being at these points made flat, they are cranked downwards to take their bearing on the spring-block, and here they are fixed to the springs, either by means of bolts passing through them, or by clips and couplings. The best plan is by the latter, as when they are bolted on, holes have to be drilled through the springs, which renders them weak at those points; the same may be said of the manner of fixing the bottom half of the spring on to the axletree.

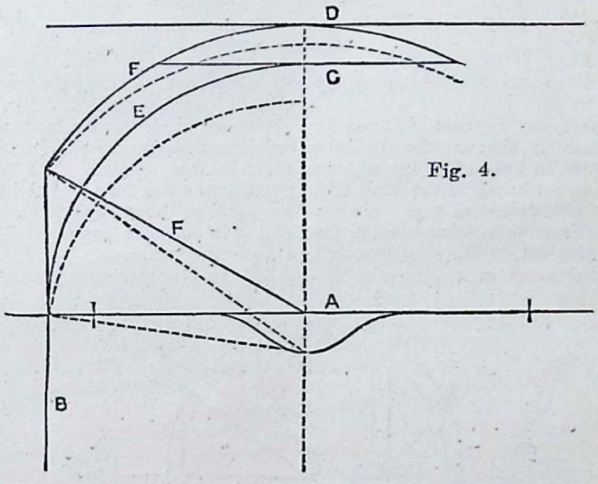


Fig. 4.

The wheel-iron, bed-clip, and back-stay being in one, affords an opportunity for the smith to display both his skill and taste as a workman, as it is desirable that this piece of workmanship should be both graceful in form, and exceedingly well forged and fitted. When finished, it should fall into its position, taking all its bearings with the greatest ease, for if, in bolting on, it should be subjected to any strain in order to force it to its bearings, it will be liable to snap at the first jar it encounters on a rough road.

But the best efforts of the workman would be counteracted in this respect, if he did not have the best metal to work with, and for this reason the English coach-smith ought to possess a far better knowledge of the art of metallurgy than he does at present. We cannot enlarge here upon the various methods by which he may detect the quality of the material that is placed in his hands to mould and weld into the various forms required in his department; but for all general purposes it is desirable that he should know that perfectly pure iron is so soft and tough, and at the same time so malleable, that it can be rolled into sheets of the three-hundredth part of an inch in thickness; and that when wrought iron can be twisted, cold, into any shape without breaking, he may rest assured that it is as near pure iron as he may wish to have for the proper execution of his work.

It may not be out of place in this part of our treatise to give a few hints to the smith on the subject of fitting. It often becomes necessary, when fitting in intricate pieces, to apply the iron while it is red-hot, and if due precaution be not taken, the wood becomes charred and worthless; and in cases where there are glued joints, it may cause the loosening or breaking of these joints, and other material defects. All this may be overcome in the simplest way. No well-regulated smith's shop should be without a heat neutraliser, such as chalk. If chalk be well rubbed over the surface on which we intend applying hot iron, we can apply it almost with impunity. Plaster of Paris is a still more powerful neutraliser of heat, as it is freer from grit, and with this we can make a more perfect fit. A small quantity of the plaster mixed with water, and pressed into a manageable shape, will be ready for use in about two hours. We are quite

aware that chalk is frequently rubbed by the smith over the woodwork whereon he is about to fit his plates, but this is done in order that he may more distinctly observe where the plate takes its bearings and where it does not. This, of course, is an advantage; but if it were more generally known that chalk or plaster of Paris was a heat neutraliser, these substances would be more freely and more universally applied.

We have already pointed out the advantage of compassing the beds of the fore-carriage. It enables a carriage-maker to place his front wheels farther back than the straight bed will permit of, and it renders his work more compact in appearance; moreover, the closer the front and hind wheels are brought together, the better is the body supported, and the lighter it may be constructed. Another advantage is also supposed to be gained by this process, namely, that of lessening the draught of the vehicle on the common road. We say "supposed" advisedly, for there are as many opponents as advocates of the theory, neither are we in a position to speak authoritatively on the relative merits of the long and the short lock, under which heading this question has been largely discussed in the trade, for the facts of the case have never been thoroughly investigated.

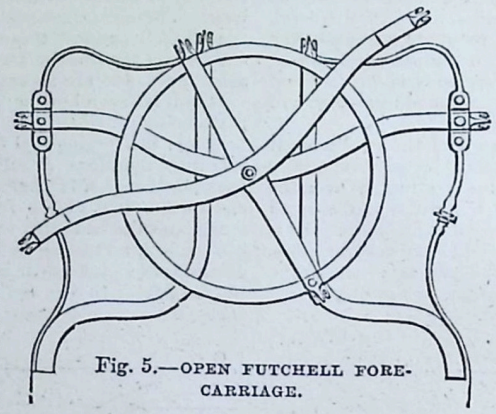


Fig. 5.—OPEN FUTCHELL FORE-CARRIAGE.

Much ingenuity has been displayed, and expense incurred by those who advocate the theory that to shorten the distance between the hind and front wheels is to lessen the draught, in the production of various inventions for bringing the hind and the front wheels of a four-wheeled vehicle closer together than the common lock will permit of. These inventions consist, for the most part, of patent wheel-plates with sliding centres, but we have no faith in any of them, inasmuch as a sliding centre cannot be so firm as a fixed one, and the peculiar action which their construction involves, no matter how each may differ from the other in detail, has the effect of throwing the front part of the body right off from its central bearings as the wheel locks round; moreover, we are far from satisfied that they fulfil the object for which they are intended.

We have frequently asked these inventors, "Have you ever tried whether or not your theory of the long and short lock is correct?" and have invariably obtained the same answer, "No." There are as many conflicting opinions on this subject now as there were ten or twenty years ago, and no efforts have been made to arrive at a satisfactory conclusion. About ten years ago, the question appeared to have assumed quite a popular character, and at least one coach-builder considered that the time had come to fully investigate it. It was suggested that a series of experiments should be tried, not with mere models, but that they should be carried out upon the high road with carriages themselves over given distances and gradients. According to this plan, proper indicators were to be attached, and the result registered mechanically, that would form a basis upon which some satisfactory conclusion could be worked out.

But the objection to this proposition was, that it would be attended with a good deal of expense. It was proposed, however, to raise a five-shilling subscription, and that as soon as a sufficient sum, say £30, was obtained, or rather promised, a meeting should be convened and a committee formed, the duty of which should be to give due publicity to the undertaking, whereby general interest would be excited and the necessary funds realised.

So sanguine was the promoter of this scheme, that he flattered himself thousands would come forward willing to lend their aid in defraying the expense, and he actually proposed what was to be done with the surplus funds, after all the necessary instruments had been purchased, and all the various expenses of the undertaking incurred. Nevertheless, the proposition fell to the ground, and although one or two coach-builders may have partially satisfied themselves on this important subject by imperfect experiment, the subject is still left for decision practically in the hands of coachmen, whose supposed experience is largely accepted as evidence.

But while the decision is thus left in abeyance as to the desirability of throwing the front wheels farther back for the purpose of lessening the draught, Mr. Offord, of Wells Street, Oxford Street, and Brook Street, Grosvenor Square, has been exercising his ingenuity to throw the back wheels farther forward, and has produced a brougham that offers peculiar advantages in this respect. The hind wheel appears to be placed right across the door, but the facilities for ingress and egress are equal to those given in the ordinary brougham. We purpose giving in our next paper an illustration showing a carriage of this description.

This novel contrivance presents nothing singular in appearance, while a very little reflection will satisfy a practical thinker that the advantage sought after of lessening the draught of the carriage, must be obtained far more completely than by throwing the front wheel backward. The wheels to a vehicle are what the legs are to an animal; they are its locomotive power. The ordinary mode of construction of our four-wheeled carriages necessitates attaching a support or pump-handle at the back part of the body; this becomes the bearing for the hind wheels, which, for the most part, are placed *beyond the extremity* of the body. Did ever any one see an animal that had its hind legs placed beyond the extremity of its body? Surely the silent teachings of Nature must be worth something in such matters, and we can see in this plan of shortening the distance between the hind and front wheels some solid practical advantage.

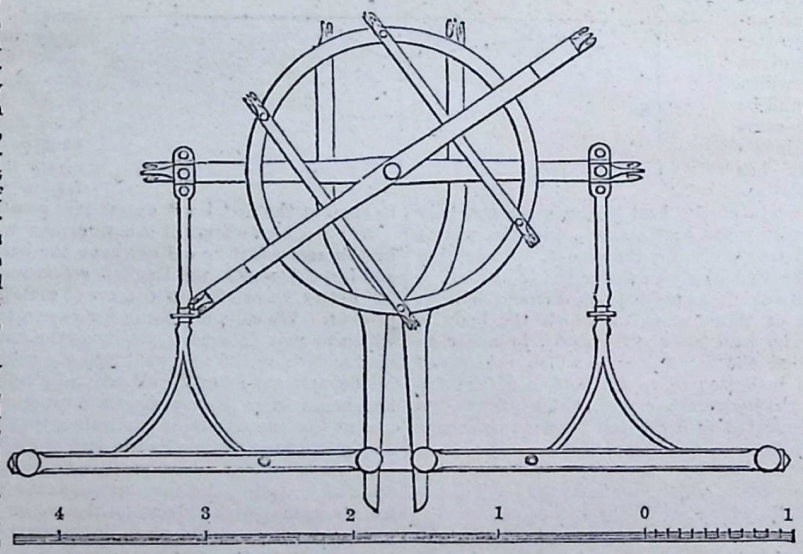


Fig. 6.—CLOSE FUTCHELL FORE-CARRIAGE.

But there is another question to be discussed in relation to draught. It is a common error that the springs of a carriage perform no other office than that of giving elasticity to the body and ease to the riders. It has been proved, however, by actual experiment carefully carried out, that they perform an important part in the economy of draught. This, however, we will discuss in our next paper.

INDIAN RUBBER.—III.

BY GEORGE GLADSTONE, F.C.S.

COMPOUNDS WITH PITCH AND TAR—CEMENTS—MASTICATION—PROPERTIES OF MASTICATED RUBBER—PURIFICATION—KNEADING—CUTTING INTO SHEETS AND THREADS—MAKING OF ROUND THREAD.

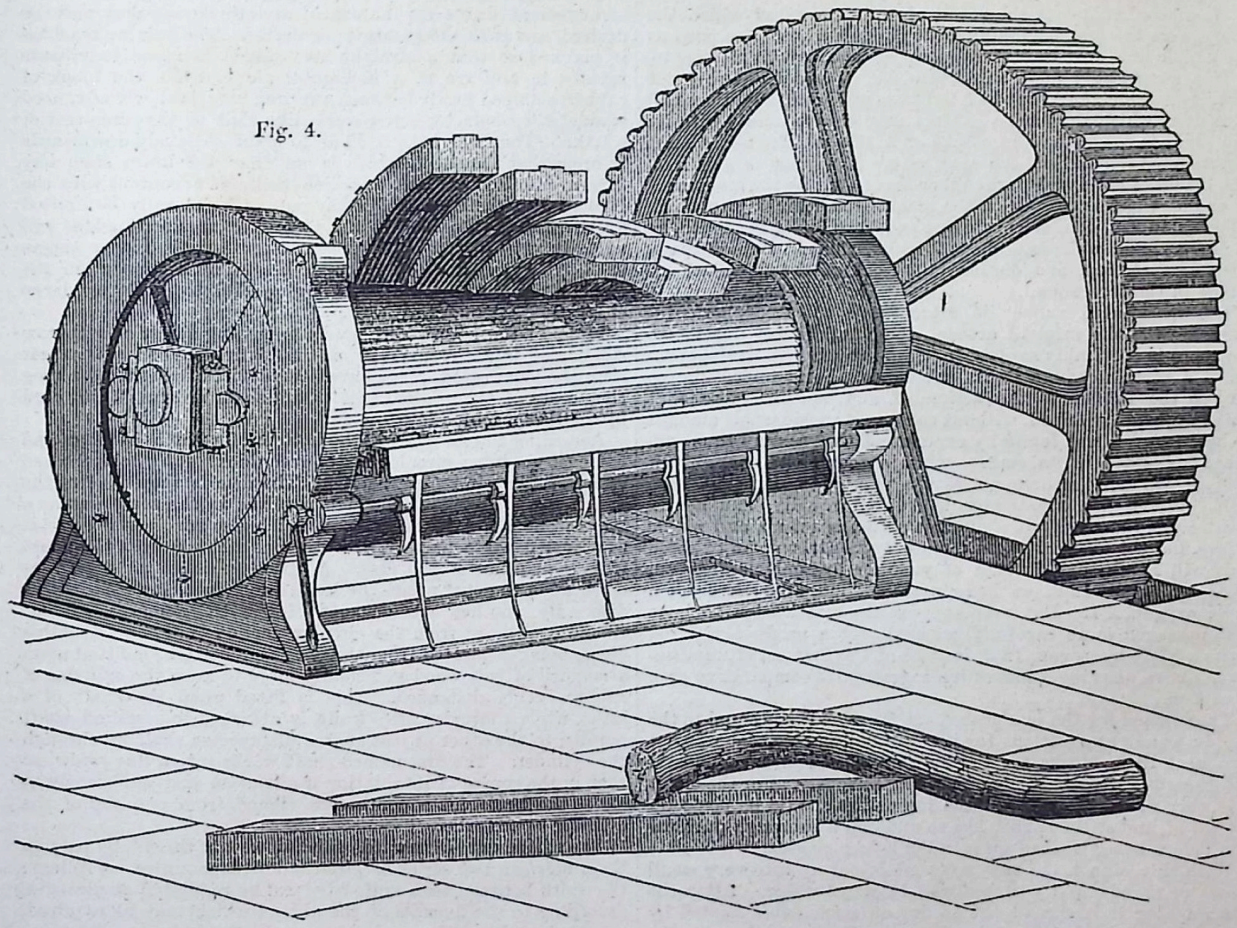
In addition to the applications of a solution of Indian rubber mentioned in the last article, there are others in which it may be used with advantage.

Thus a compound of it with pitch and tar possesses also very useful properties. It may be employed in making cordage; or for saturating canvas, or the felt or paper used under the sheathing of ships or roofing of houses; or as a substitute for the common pitch in preserving woodwork from the effects of wet. The product will be more elastic and durable, as well as less affected by the exposure to the weather, than either of the articles with which it is compounded. The Indian rubber must be first dissolved in naphtha, oil of turpentine, or other suitable solvent, and it is then ready to be mixed with the others. Tar will combine with it readily at an ordinary temperature; but the pitch must, of course, be melted sufficiently to become fluid, and must be maintained at such temperature until the mixture with the solution is complete. Either or both these articles may be used according to the purpose for which the compound is wanted.

A glue of a very adhesive character can also be made, in which Indian rubber forms an important ingredient. A pound of the rubber should be dissolved in four gallons of naphtha, and allowed to stand until it becomes about as thick as cream. To this about double the quantity, by weight, of shellac should be added, and the whole heated in an iron vessel and well stirred until the lac has thoroughly combined with it. It can then be poured out into shapes, and will solidify as it cools. When the glue is wanted for use, one of the cakes has only to be put into an iron pot and heated up to about 250° Fahrenheit, when it will commence to liquify. It should be applied with a brush to the surfaces of the wood which are intended to be united as quickly as possible, and then the pieces should be pressed together for a short time. As soon as the glue has thoroughly set the adhesion will be so perfect that the wood itself will break sooner than the composition will give way.

Another cement is prepared by heating the caoutchouc up to 398° Fahr., at which point it no longer dries on cooling (which it does when melted at any lower temperature). To a pound of this add half a pound of powdered slaked lime, and work them up together. The mixture will form a tenacious non-drying substance, very convenient in many scientific operations, as in temporarily closing glass vessels air or water-tight, which, at the same time, can be loosened with the greatest readiness whenever desired. If a permanent drying cement is wanted, it is only necessary to add half a pound of red lead to the above, and work up together all the three ingredients.

Fig. 4.



We must, however, take leave of the applications of Indian rubber by the aid of solvents, and consider how it can be utilised without their assistance. Only very small blocks or sheets could possibly be cut out of the irregular-shaped pieces received from abroad, and in doing this a great amount of waste was inevitably incurred, which, in so high-priced an article, became a very serious matter. Attention was therefore turned to the question of making use of these waste cuttings. The property which caoutchouc possesses of uniting together whenever two fresh cut and clean surfaces are brought into contact, cannot fail to have attracted the notice of every worker in the

article. Mr. Hancock tried to avail himself of this in his earliest experiments, and constructed a small hand-mill, consisting of a hollow drum of wood, in which a cylinder of the same material turned; the inner surface of the drum and the exterior of the revolving cylinder were armed with spikes and sharp-cutting edges. The labour of turning it was very great, even when operating on a charge of only two ounces; but it was found to produce the result intended. The shreds of Indian rubber were lacerated and torn in all directions; but the newly-exposed surfaces adhered as fast as they were laid open, and gradually united into one lump, homogeneous in the centre, the surface merely being perforated or indented by the teeth. The principle was thus established, and it only needed development and adaptation from time to time to the growing necessities of the trade.

Masticated rubber is the result of the process, of which the above were the first beginnings. It is not altogether so good as the article produced in Nature's laboratory; but, at all events, it is a remarkably good substitute for it, and has two great advantages:—(1st.) It can be freed from all the adulterations and impurities which the native Indians may choose to mix with it; and (2nd) it can be had in blocks of a size which it is almost impossible to make on the spot where the juice is gathered. The blocks of solid and pure rubber turned out by the machinery of one of the largest works, the masticator belonging to which is figured in Fig. 4 in the preceding page, are 6 feet in length, by 12 to 13 inches wide, and about 7 inches thick. Two of these, after compression, and one as taken out of the machine, are shown in the foreground.

The masticated rubber is more liable to atmospheric influences than the original article, which is probably due to the heat that is inevitably evolved during the process having produced a certain change in its substance. It is impossible to subject the rubber to the action of any machine like that which we have described, without causing a considerable amount of heat; and it was found by experiment that a lump thus produced indicated in its centre, when speedily cut open, about 280°, which is, of course, above the point where it begins to melt. But if the masticator is worked rapidly, and a still greater heat engendered, a distinct action is set up, and we no longer find the product to be a pure hydrocarbon; an oxidised body will result, and instead of yielding by analysis—carbon, 87·2; hydrogen, 12·8, we have now—carbon, 86·6; hydrogen, 11·3; oxygen, 2·1. But even suppose the mastication to have been managed more carefully, we shall get a product yielding carbon, 87·7; hydrogen, 12·3, instead of the first set of numbers given above, showing a loss of hydrogen and a comparative gain of carbon.

The demand for the masticated article was always equal to the supply, as new applications for it continually arose. It was cut into neat little blocks for the stationers, and into thin sheets and threads for various manufacturing purposes. For the latter it is very necessary that all the impurities should be perfectly got rid of, and so the rubber has to undergo a thorough purification before being worked up into the larger masses.

With this object the raw material is cut up into very small pieces or shreds, and agitated well in warm water. After the first washing it is spread out to dry on iron plates heated by steam, and turned over from time to time to separate any adhering dirt. It is again washed by being passed between rollers under water; and these processes are repeated as long as any dirt is found to be carried away by the water.

The purified rubber has then to be put into another machine to expel all the moisture and knead it into one mass. The kneading machine is usually made in the form of a cylinder placed horizontally, through which passes a shaft with two or three rows of projecting bars, which rotate against a series of fine chisel-shaped teeth. Sometimes more than one of these machines is adopted, the arrangement of the compressing and cutting instruments being varied, so that the greatest measure of effect may be attained in forcing out the moisture, and also the air, which may get included within the substance of the rubber. The expulsion of the water is materially aided by the heat evolved during the mastication, sufficient, indeed, to convert the water into steam, which escapes with violence. In the later steps of the process the revolving cylinder has often nothing more than a corrugated surface, which will hold with sufficient tenacity the roll of stuff submitted to its action.

The piece of masticated rubber is then taken out and put into a press, usually worked upon the hydraulic principle. In some factories it is compressed into long rectangular blocks, as shown in the drawing; in others it is pressed into the ordinary form of a cheese. The whole force of the press must not, however, be exerted at once, and the maximum force to be applied must be maintained until the rubber is quite cool, when it will retain its figure after the compressing force is withdrawn.

The blocks thus made are principally used for cutting into sheets and threads, in which forms Indian rubber is largely employed for manufacturing purposes. Any one who attempts for the first time to cut a piece in two will find it not so easy a matter, as the knife is sure to stick fast. This difficulty is obviated by directing a jet of water so that the cutting edge shall always be kept wet; and by the following mechanical arrangement sheets can be cut of any thickness that may be desired, and with the greatest regularity. The cutting machine is planned so that a straight steel blade is made to vibrate rapidly to and fro in a horizontal plane, while the block of rubber, clamped firmly between two iron bars, is slowly advanced against the blade by screw-work, like that of the slide-rest of a lathe. The knife is so fixed as to slant obliquely downwards in order that the sheet, which is cut from the lower side, may turn over as soon as cut and free itself from contact with the blade. The sheets, as originally cut, will naturally be limited to the size of the block; but two clean fresh-cut edges will unite so perfectly on being pressed together, that large sheets used to be thus made from small blocks, at a time when the masticators were not sufficiently powerful to work up large charges.

Many of the sheets were used for cutting either into narrow ribands or into thread; but as the native rubber is stronger than the masticated, plans have been devised for cutting a long riband out of the original bottles, which is afterwards reduced by another machine into thread.

According to one process, the bottom of a bottle is taken and flattened out into a circular disc of even thickness by being heated under pressure in an iron mould. The disc is then fixed to the end of a horizontal shaft, which revolves in the same way as a lathe, while a circular steel knife, which also revolves rapidly, is so adjusted as to pare off a continuous strip of even thickness from the surface of the disc. A little stream of water trickles down upon the spot where the knife comes into contact with the disc. By another arrangement of the machinery a similar riband can be cut from the circular portion of the bottle: this piece, being separated from the neck and bottom, is fitted upon a mandril of soft wood sufficiently large to keep the cylinder of rubber evenly distended. This is fitted upon the shaft of a lathe, while a circular steel knife is attached to a second shaft parallel to the other at just such a distance as shall cut through the cylinder. The first-named shaft works into a fine screw, so that in the course of its rotation it advances just sufficiently to make the knife cut a continuous riband from one end of the cylinder to the other.

The ribands are afterwards subdivided into thread, by passing them between two series of circular knives mounted on rollers; the width between each knife-edge can be regulated at pleasure, according to the fineness of the thread which may be required, by varying the washers which separate the knives. These are usually made of brass in sets of different thicknesses. Each series of knives is screwed firmly together, and then, on the rollers being made to revolve, the riband is drawn between them and cut into as many threads as the width will allow. If the threads get broken during the subsequent manipulation, or if they are originally cut from short pieces and it is desired to lengthen them, they can be easily joined by cutting the two ends on a slant with a clean dry pair of scissors, and then pressing the two fresh cuts together between the finger and thumb. The warmth of these will be sufficient to make them adhere perfectly.

It is evident, from the character of the machinery above described, that the threads so manufactured must be rectangular; and those who have pulled a bit of elastic to pieces will often have observed that such was their form. The French have the credit of introducing the cylindrical thread, which is not produced by any cutting apparatus, but by one adapted to a totally different principle. It will be remembered that in the previous article bisulphide of carbon was mentioned as one of

those liquids in which caoutchouc is but sparingly soluble, while alcohol exercises no effect whatever in that direction, but rather the reverse. Advantage was taken of this, and a combination prepared, containing 95 per cent. of bisulphide of carbon and 5 per cent. of alcohol, which was found not to dissolve the substance, but only to reduce it to a pasty consistence. After twelve to fifteen hours' exposure to this compound the paste is ready for use; it is then put into a cylinder, the lower part of which is perforated with a series of circular holes, usually about one-twenty-fourth of an inch in diameter, and through these the pasty mass is forced by the pressure of the descending piston, while an endless web of velvet, which travels at an appropriate rate, receives upon its surface the semi-solid threads of rubber as they pass out of the holes, and carries them off to a proper receptacle, where they dry by evaporation of the highly volatile bisulphide of carbon before they have the opportunity of sticking together.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXVIII.—ROMÉ DE L'ISLE.

BY JAMES GRANT.

Jean Louis Baptiste Romé de L'Isle, the celebrated French crystallographer, and the first who brought the study and science of mineralogy into prominence, was born in 1736, at Gray, a small town in the east of France, in Franche-Comte, or Haute Bourgogne, long an independent province, and only incorporated with France in 1678. At an early period of life he was appointed secretary to a corps of engineers, and in this capacity went to the French East Indies. The period of his first return is unknown, but in the year 1757 he was again on service in the East, and fought at the defence of Pondicherry, a town on the Coromandel coast of Hindostan, when it was besieged by the British forces under Colonel Coote in 1761. The garrison consisted of the regiments of Lorraine, La Marine, de Lally (of the Irish brigade), the volunteers of Bourbon, the battalion d'India, and other forces, and the defence was long and desperate, being conducted by Arthur, Count Lally, an Irishman in the service of Louis XV. The garrison became prisoners of war, and on this occasion plunder to the value of two millions sterling fell into the hands of the British.

In 1764, after three years of captivity, Romé de L'Isle and Count Lally about the same time returned to Paris, where the latter was arrested on certain pretended charges connected with the fall of Pondicherry, and notwithstanding his long and gallant services, was taken from the Bastille, and cruelly beheaded in the Place de Grève, with a gag in his mouth, to prevent him from addressing the people.

With the capture of Pondicherry the career of De L'Isle as a military engineer ended, and he applied himself to the study of natural science. In 1766 he published a "Letter to M. Bertrand on Fresh-water Polypes," in which he considered the polypus as a tube for the reception of an infinity of small isolated animals. Having commenced, along with Le Sage, the study of natural history, he directed his attention particularly to mineralogy, and his first work was a "Catalogue Raisonnée" of M. Davila's collection intended for sale; and this work appeared in 1767 in three volumes octavo, and by this he was led into an accurate examination of the forms of crystallised bodies, and to the construction of a system of crystallography.

His first essay on that subject was published in 1771, and contains 110 specimens of crystals; of these the great naturalist Linnæus knew but forty. The production of this work extended his fame among the learned. His correspondence was courted by Linnæus, and he was honoured with a seat in most of the academies of Europe.

His own countrymen were, however, the last to discover any merit in Romé de L'Isle, and from the circumstance of his having published eight explanatory catalogues of collections of minerals between 1767 and 1782, they were somewhat disposed to regard him more as a scientific drudge than as a learned philosopher.

In 1778 he published an explanation of Le Sage's theory of chemistry, and one year afterwards appeared his work entitled, "L'Action de Feu central, banni de la surface du Globe, et le soleil rétabli dans ses droits."

His first work, however, by which he will be long and honourably remembered, appeared in 1783 under the title of "Crystallographie; ou, Description des Formes propres de tous les Corps du Règne Minérale," in four volumes octavo.

The wonderful merits of De L'Isle in mineralogy are less generally acknowledged than they deserve, particularly in France, though recent mineralogists have been frequently astonished at the accuracy of the descriptions given by this author, even of such substances as were afterwards confounded with each other by Haüy in his "Primitive Form of Crystals," and others who have copied him.

The power of observation is displayed in every page in a very remarkable degree, joined with much good sense, close reasoning, and vast mineralogical knowledge. His forms of crystals, however, are frequently far from affording the pleasing effect of geometric perfection, which so charms the eye, in the diagrams that adorn the great work of Haüy. They evince, however, the hand of a master whose eye could grasp, and whose pencil could reproduce, the peculiar character of the individual crystals which he represents, and which is often preserved more correctly in those sketches than in better executed drawings.

In perusing the second edition of "Crystallographie," the student will always find a great deal of instruction, the result of more than twenty years' constant and well-directed exertion on the part of Romé de L'Isle; but even those who may be, perhaps, already proficient in that science, will find pleasure by discovering in his works that they have been anticipated in their descriptions. With perfect propriety it may be said that however ingenious the views of Haüy may have been in regard to the property of cleavage, he could never have succeeded in establishing them as a general system had he not possessed the observations and drawings of the ex-engineer of Pondicherry.

The latter met with all the opposition commonly incidental to new ideas, or to that degree of accuracy which is far beyond what had been customary before; but the prejudice had worn away when Haüy's system appeared, and won the plaudits due to its own merits and those of Romé de L'Isle. The former was always generous enough to acknowledge all he owed to the latter; he supplied the link in the chain which made his observations useful, by introducing general views in crystallography founded upon geometrical processes, and by giving to every substance determined to be a separate species a particular name.

Regardless of the two great points, which, according to Linnæus, like the thread of Ariadne, lead us through the maze of the variety of Nature—the systematic disposition and denomination of the species—Romé de L'Isle, in his paper entitled "Des Caractères Extérieures des Minéraux," has given principles for the determination of the latter, apart from chemical analysis, and these principles will stand every attack, and must ever remain one of the most valuable disquisitions proposed on the subject to the public; and these ought to be studied by all who wish information on a subject so important.

Romé de L'Isle was the first to raise mineralogy to the rank of a well-defined branch of natural history, in spite of the pretensions of chemists, who, even at that time, when the knowledge of this science was crude and imperfect, particularly so far as minerals were concerned, undervalued everything that was constant in minerals, and that they might fail to understand. In a great measure all this may account for the reason why the works and researches of Romé de L'Isle have been so neglected, and though amply used by Haüy and others, have never had that degree of influence to which their excellence entitled them.

Besides the works already enumerated, he published, in 1787, "Extérieures des Minéraux;" and in 1789, "Métrologie, ou Tables pour servir à l'Intelligence des Poids et des Mésures des Anciens, d'apres leur Rapport avec les Poids et les Mésures de la France."

Still his own countrymen ignored him.

According to the editors of "Rozier's Journal," in 1789, we find it stated that "M. Romé de L'Isle, whose name will last so long as science shall be cultivated, though honoured by foreigners, and associated with the most learned societies in Europe, has still been elected a member of *no* academy in France; nor has he any place. Places and pensions our own academicians have now contrived to banish away with the prodigality of courtiers; but (we hope) the public esteem will indemnify this valuable citizen for an injustice which the nation disavows. Academical

aristocracy is not less injurious to the republic of letters than patrician aristocracy to political constitutions."

But no honours awaited Romé de L'Isle in France, where the downward course of the Republic had begun.

His "Métrologie" contained a system of tables for understanding the weights and measures of the ancients, and in a particular manner for determining the value of Greek and Roman money, and the proportions they bear to the present weights of coin and money in France.

A work of this kind is very remote from the subjects about which our crystallographer was chiefly conversant; but his whole time was dedicated to labour, and he lost none of it in cringing among courtiers, or seeking by intrigue, cabal, or solicitation to gain place or pension, though age was creeping upon him.

It had been talked of at that time to have uniform systems of weights and measures in Europe. "If so," says the editor of "Rozier's Journal," with reference to the last work of Romé de L'Isle, "then imitate the measures of the ancients, as given there, either by adopting the geometrical foot, taken from the measurement of a degree of the meridian, or the pythic foot, taken from the length of a pendulum vibrating seconds, which still (1789) exists at Marseilles and Genoa, under the name *palin*, and we might substitute *stadium* for *mile*."

Some time before his death Romé de L'Isle was blind, and he died of dropsy, at Paris, in March, 1790, in the sixtieth year of his age.

CAPITAL AND LABOUR.—VIII.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

CO-OPERATION.

The struggle between the workman and employer is always active, and always will be actively carried on, as long as their present relations subsist. The cause for this permanent unsettlement has been already stated, but it bears repetition partly because of its importance, partly because it is rarely apprehended. It arises from the fact that both employer and workman are paid for their labour, both receiving wages; and because there can only be a very imperfect means for adjudicating what is the portion which each of the parties should receive, or if they differ, there is no effectual process by which the rival claims of both should be satisfied. It is true that the adjudication is easier in some cases than it is in others, but it is imperfect in all, and it is certain that the settlement of no trade dispute ever leaves both the parties in the arrangement convinced that the decision or compromise has been thoroughly equitable, and therefore incapable of being challenged.

The rivalry, then, between the employer and the workman can never come to an end as long as the relations of employer and workman subsist, though under certain circumstances and in certain callings it can be greatly modified. It is only when the functions of capitalist (in the popular sense of the word) and labourer are united in the same person, that those expedients by which the workman attempts to obtain better terms for his labour from his employer will be understood and adjusted. This change may occur either by the workman finding his own customer —*i.e.*, being in business for himself—or by his uniting in a trade partnership with other workmen, with the distinct purpose of using his own capital as well as his own labour under such an association. The latter form of action is called co-operation. This word is convenient, because its significance is vague and general.

Certain callings are, it appears, peculiarly capable of being carried out on a small scale. One of these is agriculture. There is abundant evidence to the fact that all kinds of agriculture may be very advantageously carried out under a system of small holdings, and that certain agricultural processes can be carried on in no other way to advantage. Such, for instance, are the successful cultivation of the vine, and other fruits, the production of silk and similar operations which need incessant and minute attention. It is clear that dairy-farming is most advantageously practised on a small scale. Similarly, there are other branches of industry which have the same characteristics. Certain kinds of mining are most likely to be successful when the miner has a notable share in the returns of the mine. So again, some of the nicest work of the gunsmith is done by operatives who work on their own account.

If the workman is directly interested in the success of his work, we may anticipate that he will be more than ordinarily active in the industry which engages his attention. If the business be one of dealing only, the participation in business profits makes the individual more brisk, more pushing, and more cautious. If it be one of production, he is attentive to little economies, the saving in which, though it seems small, amounts, when the number of operations are many, to a considerable quantity on the side of business profit. So thoroughly is this understood by men of business, that it is a very common thing for merchants to pay their agents by a certain share in the nett profits of the calling in which they are employed. It is a growing custom with manufacturers, owners of collieries and the like, to admit their workmen to a share in the profits, and therefore to communicate to them full information as to the details of their business. In such cases, the workman, though he be not in law a partner with his employer, is in fact occupying such a position, and such associations of employers and workmen are frequently called co-operative undertakings, since the arrangement partakes of the nature of co-operation, as the word is popularly understood.

They are not, however, exactly the same. In the co-operative system, the workman finds all that the capitalist supplies, and contributes his manual labour also. Of course his object in doing this is to appropriate that to himself which the employer generally secures under the name of profits. He may attempt to obtain this advantage, either in his character of a consumer, or in that of a producer. He may seek to bring himself, as a purchaser of the goods which he requires for his subsistence or comfort, nearer to other producers by seeking to get rid of the middleman or dealer. This, under the system of what are called co-operative shops, is the most familiar example of such joint or co-operative action in this country. Rightly or wrongly, consumers have thought on certain occasions that the profit of the retail dealer is excessive, in proportion to the service which he renders, and that he could on many grounds be dispensed with, to the convenience or advantage of those who buy goods. Similarly it is asserted, with more or less justice, that the retail trader is tempted to various kinds of fraud, and there is evidence that the fraud is frequently practised. It is also said that a system of co-operative shops is not only an advantage to the purchaser, but indirectly a great advantage to the producer. If it be the case that in such shops the purchaser makes a saving of expense to the extent of 10 per cent. on the cost of that which he buys, it is plain that he has 10 per cent. on his income more to spend; and as in accordance with what has been stated above, the stimulus to labour is the demand of those who require the objects on which industry is exercised, the saving of 10 per cent. in the cost of supplying one's wants, is an addition of 10 per cent. to the means which the consumer has for calling the producer into activity.

This kind of co-operation, however, though it may give the purchaser a larger command over the necessaries and conveniences of life, and may supply him with better as well as with cheaper goods, is not the most important kind of co-operation. Much more significant is the co-operation of production—*i.e.*, the union of workmen together for the purpose of supplying the public with goods. Such a form of co-operation has been adopted with great success, and is growing in Northern Germany, a system having been established in that country, under which banks are formed to receive the savings of workmen, with a view to such savings being employed for purposes of business. Undertakings of a similar kind have been entered on in this country, particularly in the Lancashire district, where there are cotton and other mills, the owners of which are the artisans who work in the building.

In all these associations, the first necessity, and yet very often the most difficult requisite to secure, is the discipline and obedience of those who are employed and are the owners of the undertaking. A great manufactory is like a regiment of soldiers, the effectiveness of which is due to its drill and deference to lawful and necessary orders. Such an establishment needs a manager, whose commands must be cheerfully and implicitly obeyed. It is not always easy to find a competent manager, and it is in the same manner not always easy to find docile workmen. It is stated, and perhaps with some justice, that the characteristic of docility is not general among English workmen, and that the absence of this quality

is a powerful hindrance to the development of the co-operative principle in this country. But there is no doubt that any future improvement in the condition of the English artisan or workman depends mainly on the success with which co-operation, with its economies, and indirectly, its high moral training, can be adopted.

It is an error to suppose that co-operation is available only for manufacturing operations. It is equally susceptible of application to agriculture. In point of fact, it is the only means by which a system of small tenancies, which most observers have admitted to be a great boon to the agricultural population, may, in addition to their own special merits as a form of industry peculiarly fitted for certain operations, successfully rival large farming. The large farmer is able to economise labour by the purchase and use of costly machines. Now such economies are out of the question in the case of small farmers, if they are to purchase the machine as individuals. But there is no reason why they should not unite to purchase them, for just as in great joint-stock undertakings the aggregate of small shareholders represents much greater wealth than the subscription of the richest individual, so a combination of small farmers could readily purchase the most perfect machinery, and so combine all the advantages of their own tenure with those which are admitted to belong to a system of large holdings.

PHOTOGRAPHY.—XII.

By J. C. Leake.

COPYING MAPS AND DRAWINGS—FORM OF LENS—ADJUSTMENT OF CAMERA AND STAND—COPYING OIL PAINTINGS.

The reproduction of maps, plans, and drawings is one of the most useful applications of photography. By means of the camera, copies of drawings or manuscripts may be produced in a fraction of the time which would be needed when they are copied by any of the ordinary processes of engraving; while their accuracy is such as to be beyond suspicion. For these reasons as well as others, it is of importance to all engaged in the mechanical arts, especially such as building and engineering, that they should be able by means of the camera to reproduce working drawings or plans, which, by the aid of this art, they may do in infinitely less time than would be required to make an ordinary tracing. In order, however, to make a photograph of a map, or any drawing, some care is necessary and certain precautions must be observed, as it is only when properly used that photography is capable of rendering good and trustworthy copies. We will, therefore, in this paper proceed to give such instructions as may enable the operator to ensure perfect accuracy in his work.

The first matter requiring attention is that of the lens employed, as although common landscape lenses or the ordinary portrait combinations may give good definition and perfect sharpness of line when used for ordinary purposes, they mostly distort the image more or less. In copying drawings or maps, of course, this cannot be tolerated. Perfect accuracy is an absolute necessity, especially where a map or drawing has to be copied in several portions and afterwards joined. It is therefore usual to employ a lens constructed specially for the purpose, in which flatness of field, perfect definition, and freedom from distortion are combined to the greatest degree possible. There are various instruments now produced by both English and foreign makers, in which these qualities are combined in a remarkable degree, and in the purchase of which the operator cannot do better than be guided by some respectable optician or photographer.

The camera also will most probably require some alteration or re-arrangement in order to adapt it to the focus of the copying lens, which will be found to be very much longer than usual. If a special camera be not employed, the body of the ordinary one may be lengthened by fitting a cone of wood, which may support the lens; or by the insertion of an extra sliding box arranged in the centre between the front and back of the original camera. Where, however, much work of this description is required, it is better at once to procure a properly made instrument with a bellows body, and rack-work for adjustment, as it is well nigh impossible to produce really first-rate and accurate copies without.

The stand should also be one of extreme strength and steadiness, capable of being easily moved and adjusted, and of such weight as not to be liable to the slightest vibration, which would, of course, render the lines of the drawing in a blurred and indistinct manner.

A stout board well clamped, and perfectly flat, of sufficient size to support the picture or drawing to be copied, must also be provided, and this must be fixed so as to ensure perfect steadiness, either upon a stand, or to a wall in some convenient and well-lighted situation.

The lighting of the surface to be copied is a matter of considerable importance, as upon this will depend much of the perfection of the copy. If the light be allowed to fall obliquely upon the surface, very much of the texture of the paper will be reproduced; often to the destruction, or at any rate partial obliteration, of the finer lines. The best method is to allow the light to fall upon the drawing from the front, over the camera, and, of course, every part must be equally illuminated. The drawing must be placed perfectly flat, avoiding all creases or folds, a most important point, as these will be reproduced in the copy, and present uneven patches of light and shade. It is an advantage to copy drawings before their removal from the board upon which they have been stretched, as they will then be perfectly flat. Loose drawings may be fastened with drawing pins, but in all cases the greatest possible flatness must be secured.

The camera may now be brought into position, and should be placed exactly in front of the drawing and parallel with it. The size will, of course, be regulated by the distance of the camera from the drawing, and the focal length of the lens; and may be easily adjusted by moving the camera backward or forward as required. The exact size of the reproduction may be readily determined by experiment; but if the focal length of the lens is known, a rough adjustment of the camera may be made before commencing the work. Thus, if it be required to copy a picture the same size as the original with a lens of six inches focus, the lens will require to be placed at a distance of twelve inches from the drawing; and the plate will be twelve inches behind the lens—in fact, the lens will be mid-way between the object to be copied and the plate which receives the impression. In all cases it should be remembered that the size of the picture depends not upon the diameter of the lens, but upon its focal length. Another rule which is important is this—that a lens will not copy a larger picture than it will take. Thus a lens which will cover a plate, and take a sharp picture of three inches in diameter, may be used for copying, or enlarging a picture of that size, but not larger. It will enlarge a picture of three inches to any size, but it will not copy one of six inches to the same size, without strain and risk of distortion.

It is of extreme importance that the camera should be placed exactly parallel with the drawing, in order to avoid distortion. To ensure this the following plan may be adopted:—A square of fine lines should be drawn upon the copying-board, so distinctly as to be readily seen upon the camera-screen of ground glass. Upon the ground glass should be drawn with a pencil another square. When these lines are quite coincident the camera will be at exact right angles with the board. This will be a ready method of determining a most important point, and will save much trouble in measuring.

The proper adjustments having been made, the plate may be prepared in the usual way. The collodion employed should be one giving a rather dense image and a thick creamy film. When the plates are large the collodion should contain a full proportion of alcohol, which will materially facilitate the production of an even coating, a matter of some importance in this case. Although a newly-iodised collodion is not to be recommended, we should advise that old samples should be avoided, as they not only work very much more slowly—an important point when copying with lenses of long focus—but it is often difficult to obtain sufficient intensity. The plates should be very carefully drained, and a slip of blotting-paper inserted in the camera-slide upon which the plate may rest. This will absorb the superfluous solution and prevent stains. When the weather is very hot it is a good plan to provide several thicknesses of blotting-paper of the size of the plate, and having soaked them in cold water—if iced it will be all the better—to place them at the back of the plate. This will serve to keep the plate cool,

and, by preventing the rapid evaporation of the solution, moist, during very long exposures. The great difficulty during long exposures is to keep the plate moist, and if it once becomes dry stains and patches invariably occur. If the above precautions are taken, however, this will but rarely be the case. The nitrate bath should be of full strength and in the best possible order, kept quite clean and free from dust or floating particles of collodion, which would, of course, cause spots and holes in the film.

The exposure of the plate should be continued long enough to ensure a tolerably rapid development of the image; as if the developer be kept upon the plate too long, there will be a danger of fogging, and subsequent obliteration of the finer lines. The best developer is one of sulphate of iron, which should not be too strong, say from ten to fifteen grains to the ounce, and it should contain full proportions of acetic acid and alcohol. As soon as the image is visible, and before the lines, which will appear white, are in the least degree clouded, the action should be stopped by plentiful washing. It is but seldom that sufficient density of deposit is obtained by this operation alone, and consequently a subsequent process must be employed.

A certain amount of density may be obtained by the usual process with pyrogallic acid and silver applied before fixing; but this must not be carried very far, or some of the fine lines may become obliterated. When, therefore, a moderate density has thus been obtained, it will be found better to fix the image with the ordinary cyanide of potassium solution. Any amount of density may then be obtained as follows:—Flood the plate with an aqueous solution of iodine, made by dissolving together five grains of pure iodine and two of iodide of potassium in one ounce of water. After a minute's treatment with this solution wash the plate well, and proceed to re-develop with the ordinary pyrogallic acid solution, to which add a small quantity of nitrate of silver. If carefully performed, this method will be found of vast service in promoting intensity of the image, without the slightest danger of destroying the fineness and evenness of the lines.

Unless a very open and porous collodion be employed, there will be danger of a splitting up of the film during the drying. To obviate this a weak solution of gum arabic, carefully filtered through muslin or flannel, should be poured over the film when wet. This will dry with the film into a kind of varnish, and prevent accidents of this description.

By the method above described, drawings, maps, engravings, or manuscripts may be easily copied; but when copies of oil paintings or coloured subjects are required, some little modification may be necessary. The copying of oil paintings is one of the most difficult branches of the photographic art; and except in rare instances the reproductions are scarcely to be pronounced satisfactory. This arises partially from the non-actinic quality of the colours employed, and partly from the glossy and uneven surface of the painted canvas. In most cases it will be found better to copy oil paintings in the sun, taking care to avoid all reflections from the surface. A highly bromised collodion should be employed, and as large an aperture of the lens as may be consistent with tolerable sharpness of the image. A rather strong iron solution may be employed for development, and care must be taken not to make the negative too dense.

It very often happens that oil paintings may be copied very much more perfectly while their surface is wet, as the colours appear more transparent, and fewer of the cracks or defects are visible. We have therefore employed a solution of pure glycerine for application to the surface, and have found it answer perfectly. Equal proportions of pure glycerine and water are to be mixed, and applied with a soft sponge, in just sufficient quantity to keep the surface of the painting damp during the exposure of the plate. The glycerine must afterwards be removed, and the painting cleaned with clean cold water.

In conclusion, we would observe that all copying requires the utmost care. The plates must be most perfectly cleaned, the chemicals must be in the best possible order, and, above all, it is of no use whatever to attempt this sort of work unless the light be good. Attention to these points will ensure success, which cannot be attained without it; but as this is all that is absolutely necessary, there will be no one who is earnest in his work that cannot command it.

TECHNICAL DRAWING.—LXXXV.

DRAWING FOR CABINET-MAKERS.

OF THE METHOD OF COLOURING DRAWINGS, AND OF WATER-COLOURS GENERALLY.

It has already been said that drawings of furniture, etc., are usually executed in water-colours, and it is therefore deemed necessary to give in this place some instructions on the subject, together with a brief account of the colours generally used.

Whatever has been said in the previous lessons, by way of impressing on the student care, neatness, and attention, must be repeated here. Nothing can be more objectionable than a coarse, careless water-colour drawing of furniture. Rough sketching is no doubt adapted for the delineation of some effects seen in landscapes, where the foliage of trees, the mountainous country scenery, the ever varying effects of sky and water, are all at variance with formal treatment, and demand the bold and free pencil of the painter who can enter into the spirit of the scene, and by, as it were, magic touches, convey the impression to others; but beginners often unfortunately fall into the idea, that to draw roughly and carelessly is to draw artistically. There cannot be a greater mistake; the roughness seen in the works of the greatest painters is the result of power; they do not paint roughly because they want to hide bad drawing, but because they are so well acquainted with the exact lines on which the true form depends, that they can by a few touches indicate it better than one less educated could by the most laboured work. But the pictures of our best painters show how carefully and how conscientiously they studied every line in their earlier periods, and how gradually they arrived at that freedom which so enchains our minds when looking at their works.

But in the class of art connected with the present subject, the beauty of the subject is dependent on correct drawing, and neat and accurate work. The colour and general rendering must be *artistic;* but this term means, done *according to the rules of art*, not that the *drawing* is to be *careless* and the *colouring sloppy*.

The method of mixing and applying water-colours has been given in The Technical Educator, Vol. I., pages 31 and 57, and the following lesson is given in continuation of these.

In order to obtain the proper harmony of colour it is necessary that all the primaries should be present, either pure or mixed, in proper quantities. Thus in a design, if we have painted one part pure red, we must harmonise it by painting the other parts either in proper proportions of blue and yellow, or in green, which is a mixture of blue and yellow, neither of which exists in red.

Again, if we introduce yellow, we must follow with blue and red, or with purple, which is a mixture of blue and red, neither of which exists in the yellow.

Further, if our primary be blue, we must harmonise it with red or yellow, or with orange, a mixture of the two, neither of which exists in the blue.

The secondary colours are therefore said to be *complementary* to those primaries which do not enter into their composition. Thus orange is complementary to blue, and blue, *vice versa*, is complementary to orange.

Purple is complementary to yellow, and yellow to purple.

Green is complementary to red, and red to green.

The most beautiful effect of the merging of the colours into each other is seen in the rainbow:—Red, orange, yellow, green, blue, indigo, violet.

From the above it will be seen that when the red meets the yellow rays, the secondary colour, orange, is produced. The yellow and blue meeting, produce green. The blue and red give violet or purple, and the violet mixing with the blue produce indigo, which is a deep blue with a tinge of red in it.

When two secondary colours are mixed together they form a tertiary (or third) colour. Thus orange and green produce citrine.

Now it will be remembered that orange is composed of yellow and red, and that green is made up of yellow and blue, and therefore to harmonise with citrine we require a secondary colour, which has *no yellow* in it. This colour then must be *purple*, which is made up of blue and red only.

Purple (secondary) and green (secondary) produce the *tertiary olive*, and as purple is made up of blue and red, and green

is composed of blue and yellow, the colour to harmonise with blue is orange, which contains no blue at all.

Orange and purple produce the tertiary colour russet; and as orange is composed of yellow and red, and purple is composed of blue and red, green will harmonise with it because it contains no red.

The following are the colours mostly found in colour-boxes:—Prussian blue, sepia, burnt sienna, yellow ochre, vermilion, emerald green, lake (crimson or scarlet), Vandyke brown, gamboge, light red, Indian ink.

Prussian blue is a very fine deep colour, which works very smoothly. It is used not only by itself, but it mixes well with other colours.

Prussian blue, mixed with lake, makes a beautiful rich purple; more lake added, and the colour thinned, will produce violet.

Prussian blue, mixed with various quantities of gamboge, produces a beautiful bright green, used in colouring damask, or in shading emerald green. If more gamboge be added, it will become yellow-green, or with more blue, will become blue-green.

In mixing a green by night, it must be remembered that the light from gas or candles is not, like daylight, made up of red, blue, and yellow, but is altogether a *yellow* light. This will cause the green to look more yellow than it really is, and the green by daylight will thus appear a *blue* green. This must be guarded against by making the green mixed at night look more yellow than it is desired it should appear by day.

Indigo is a dark blue found in most colour-boxes. A colour very much like it can be made by the mixing of a little black and lake with the Prussian blue. Indigo is used for shading Prussian or other blues.

There are several other blues used in colouring drapery, the two principal of which are ultramarine and cobalt. These are, however, more expensive than the other colours, but if not in the box, they may be purchased separately. In using them, the colour must be stirred up at every brushful, as they are heavier than the Prussian blue, and separating from the water, sink to the bottom; a brushful of the mixture taken from the top is thus different from one taken from the bottom.

Ultramarine and *cobalt* are much used in designs. They may be mixed with white and lake, to produce the different shades of lilac and lavender, etc.

Sepia is a good dark-brown colour, much used for shading others, as it washes and tints off in a very suitable manner.

In commencing to paint in water-colours, the study should be begun by working for some time in sepia only. This style is called painting in *monochrome*, or *one* colour.

Vandyke brown and *burnt umber* are two very useful browns, not so dark as sepia. Both of these may be rendered warmer in tone by mixing lake with them.

Burnt sienna is a bright red-brown, and is very transparent. It is useful in shading gold or any yellow colours; or when a mixture of Vandyke brown and crimson lake has been washed over a surface, an additional tint of burnt sienna improves the colour meant to represent mahogany.

Emerald green is a bright colour, which is principally used in decorative painting, or in drapery, where it forms a good body to be glazed over by another green, for it is too cold a colour to be much used by itself. Special care is required in using this colour to keep it well mixed, as it is very heavy, and constantly sinks to the bottom. Putting the brush between the lips is always a bad habit, but it is especially dangerous when using emerald green, which is very poisonous.

Lake is a beautiful red colour. There are two shades, crimson and scarlet lake. The crimson is red, with a blue tinge, and the scarlet is red with a yellow tinge. Both these wash over the paper very smoothly, and are constantly used.

Vermilion is a very bright scarlet. It is very heavy, and thus separates from the water, or any colour with which it may be mixed, requiring to be stirred up as each brushful is taken. It is much used in ornamental painting, and may be shaded with lake.

Light red is not so bright a colour as vermilion, but is still very useful. It may be shaded with Vandyke brown or burnt umber.

Gamboge is a clear, bright yellow, which mixes very well with any other colour. It is very transparent, and lies evenly when spread thinly. Its use in mixing with blue to form green has already been mentioned. Indian yellow is much like gamboge, but much darker.

Yellow ochre is heavier than gamboge, and is neither so bright nor so transparent. It is used for colouring the lighter kinds of wood, and may be shaded with Vandyke brown, burnt umber, or sepia.

Indian ink is a full black. It is sold in sticks or large cakes. Should it have rather a brown tinge, it may be improved by being mixed with a small quantity of Prussian blue or indigo.

Several other colours may be found in boxes variously fitted. A little practice will soon enable the student to use them according to their different qualities.

FISH CULTURE—XIV.

By Greville Fennell.

HISTORY OF THE OYSTER FISHERY AT THE ISLE OF RÉ—MODE OF CULTIVATION EMPLOYED—OYSTER FISHERY IN CONTINENTAL SALT-WATER LAKES—LUCRINE LAKE—FUSARO—AMERICAN OYSTER FISHERY.

The Isle of Ré, off the shore of the Lower Charente (near La Rochelle), in the Bay of Biscay, used to be taken by most oyster-culturists as the model ground for the breeding of this mollusk; and as its history involves nearly all the practical portion of the pursuit, we give it from various reliable sources, amongst which are Francis Francis, F. Buckland, Cholmondeley Pennell, Bertram, *Chambers' Journal*, etc., supplementing such information with facts which have reached us since the appearance of such publications.

It would seem that at one time the oysters grew naturally on the submerged stones and rocks which skirt the island of Ré, and that a quarter of a century ago they were tolerably plentiful; but when steamboats were introduced, and the other resources of quick travel came to be developed, oysters began to be more largely consumed, and the beds, in consequence, were spoliated faster than Nature could supply them—a condition which lasted a long time, since for ten years or so the only oysters that could be obtained on Ré were those grown by the salt-makers for their own use, which, however, were of excellent flavour.

About fourteen years ago, in March, 1858, the present era of oyster cultivation was begun; it was inaugurated by an old soldier, named Bœuf, a chevalier of the Legion of Honour, who, in 1867, followed the business of a stone-mason on the island. It is thought by some of the islanders that M. Bœuf must have acquired his knowledge of oyster-culture by accident. He gives out himself that he had a theory of an oyster-garden twenty years before he began his present farm. His ideas on the subject, he says, were taken from Nature; and he tried oyster-culture privately for some years before he applied for a concession of public ground. At first he laid out a very small parc—it was only twenty yards square—in a style a working mason might be expected to do, the wall being composed of sea-stones. The plan he adopted to stock his first parc was to gather together all the stones he could find on the natural beds upon which any oysters had fastened, and these he laid down within his enclosure, in the hope that they would yield spat in the warm months. He was not disappointed, for in less than a year he found that he was possessed of handsome crops of young oysters. He went on selling his produce and extending his ground. Thus, in the course of a season or two, he found that he had hit on an easy way of supplementing his income; and his success, the news of which soon spread far and wide, became so catching, that many of those residing on the island, particularly at Rivedoux, where Bœuf lives, began to cultivate oysters on their own account, or, at any rate, to take an interest in the business of those who did. In fact, the moment it came to be generally known that by growing oysters—and that oysters could be grown just like potatoes, Bœuf had demonstrated—good hard money could be obtained, there began an excitement on the subject of their culture.

All this, indeed, has suffered a sad reverse; but the foregoing facts are given as cautionary, being founded upon practical experience, which will stand its ground under average conditions and circumstances. Mr. Cholmondeley Pennell, the Inspector of Oyster Fisheries, has visited the Île de Ré since the date to which we allude, and we thus summarise his report of the year 1868.

Île de Ré is, perhaps, the most celebrated of all the centres of modern French oyster-culture. The foreshores consist principally of mud, over a sandy subsoil, the line of the shore near high-water mark being, in many places, thickly strewn with a white argillaceous limestone belonging to the Oolitic group, and closely allied in structure to the lithographic stone of Solenhofen. The number of acres of these foreshores under cultivation as breeding parcs reached, in 1865, the extent of 400 acres, embracing 4,022 concessions granted since the beginning of 1857. Only 54 concessions have, however, been granted since; the numbers granted during the last five years being respectively 498, 298, 72, 3, and 54.

There are two principal differences between the method of oyster cultivation pursued at the Île de Ré and that described at most other places—the substitution of the stones for tiles as artificial collectors; and the placing of these collectors in excavations, in lieu of flush with the surrounding shore.

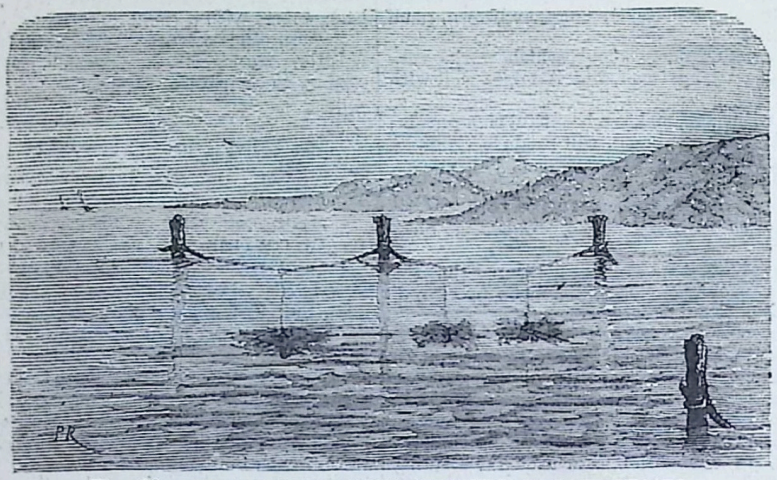


Fig. 30.—PILLARS WITH CORDS ATTACHED IN LAKE FUSARO.

The favourite size of these excavations is about 40 yards long by 20 broad, the soil being removed to the depth of one and a half to two feet. Both the walls and collectors in these excavated parcs are formed of the loose surface-stones—comparatively few tiles being used—and the bottoms are loosely paved with the same materials, of a smaller size.

The stones used as collectors average in size from one-fourth to three-fourths of a foot in diameter, and are arranged usually in rows or lines from one to one and a half feet high, and three to four feet wide. A parc of 20 yards by 40 would usually contain four or five of such rows of collectors, the walls themselves also serving the same purposes. In other parcs which are constructed flush with the foreshore, the stones are merely scattered irregularly over the surfaces.

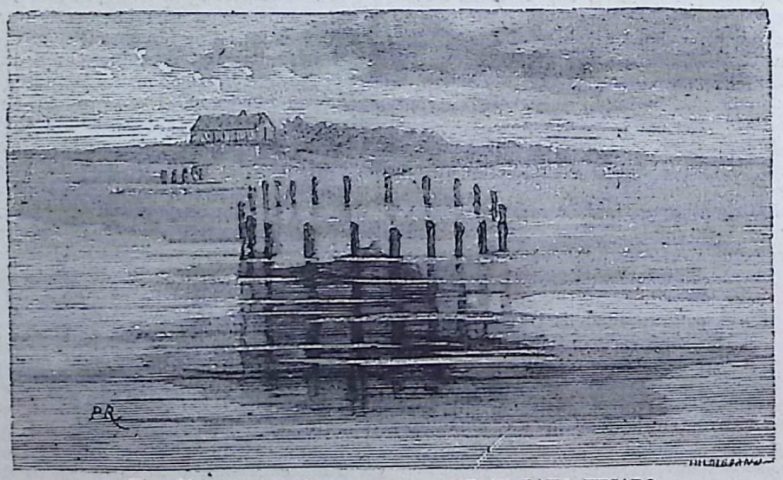


Fig. 31.—ARTIFICIAL OYSTER-BANK IN LAKE FUSARO.

The parcs are to a considerable extent situated below water-mark of ordinary neap-tides, and are uncovered about five out of every fourteen days.

The parcs at the Île de Ré were originally stocked entirely from the spat naturally brought into them by the tide; and both the inspector and commissary assured Mr. Pennell positively that the nearest oyster-beds of any sort were about 26 miles distant; and they conclude that the spat came from thence. Since the commencement of the system, in 1837, they have had good spats on the Île de Ré every year until 1862 inclusive, and since that there has been an almost complete failure. The condition of the parcs examined by Mr. Pennell fully corroborated previous suggestions that the whole of the industry was in danger of being destroyed by mud. Of the number of concessions already mentioned, 800 have been actually returned on the hands of Government, about 1,000 have been entirely abandoned, and a considerable portion of the remainder, it is to be feared, are practically valueless for collecting purposes. The excavated character of many of the parcs at the Île de Ré affords additional facilities for the accumulation of mud, which is thus protected, as it were, from the natural cleansing action of the tide. The proper time for the cleaning of the parcs and collectors is in April, May, and the beginning of June, so as to be ready for the spat, which, in the Île de Ré, usually falls towards the end of June or July. During the cleansing process the whole of the mud from the bottom, sides, and collectors should be carefully removed, and old collectors replaced by fresh ones; but this season a large proportion of the parcs have not been cleared at all, and but few have been stocked with new collectors. Only a small stock of breeding oysters now remain in some of the parcs nearest the sea, which here, as elsewhere, were regarded by the oyster-farmers as being by far the best for collecting purposes.

The young oysters are usually removed from the stones at one year old. The cause assigned by the officers for the recent failures was the improvidence of the concessionaires in selling off all their stock as soon as it was marketable, and leaving none from which to replenish the beds. Some concessions for fattening-pits have also been made at the Île de Ré, which have succeeded perfectly, both as regards the fattening and greening of the oysters laid down in them.

Dr. Bree says that no oysters, except those known as the Colchester or Pyfleet, will breed at all on our coasts. Notwithstanding the number of all kinds—Whitstable, North Country, Jersey, Welsh, Scotch, or Irish—that are laid down on our sea-beds, they never produce spawn. But if spat is brought from the above localities and laid down at Colchester, it will grow and thrive like the others.

The best oysters we get are natives, as the oysters of Whitstable, Milton, and Colchester chiefly are denominated. The small oysters, called in the trade "spat," are collected all round the coast, and deposited in the oyster-beds in localities most favourable to its development, where the greatest care is taken of the beds, star-fish and other vermin destructive to the oyster being carefully kept away from them, until the fish are fit for sale, when the oysters are dredged up, and any spat which may be adhering to them is removed and returned to the water. Vast quantities of oysters were brought from Jersey, where the oyster-beds were unusually large and fertile. The coarsest and worst oysters we obtain are the Channel and deep-sea oysters.

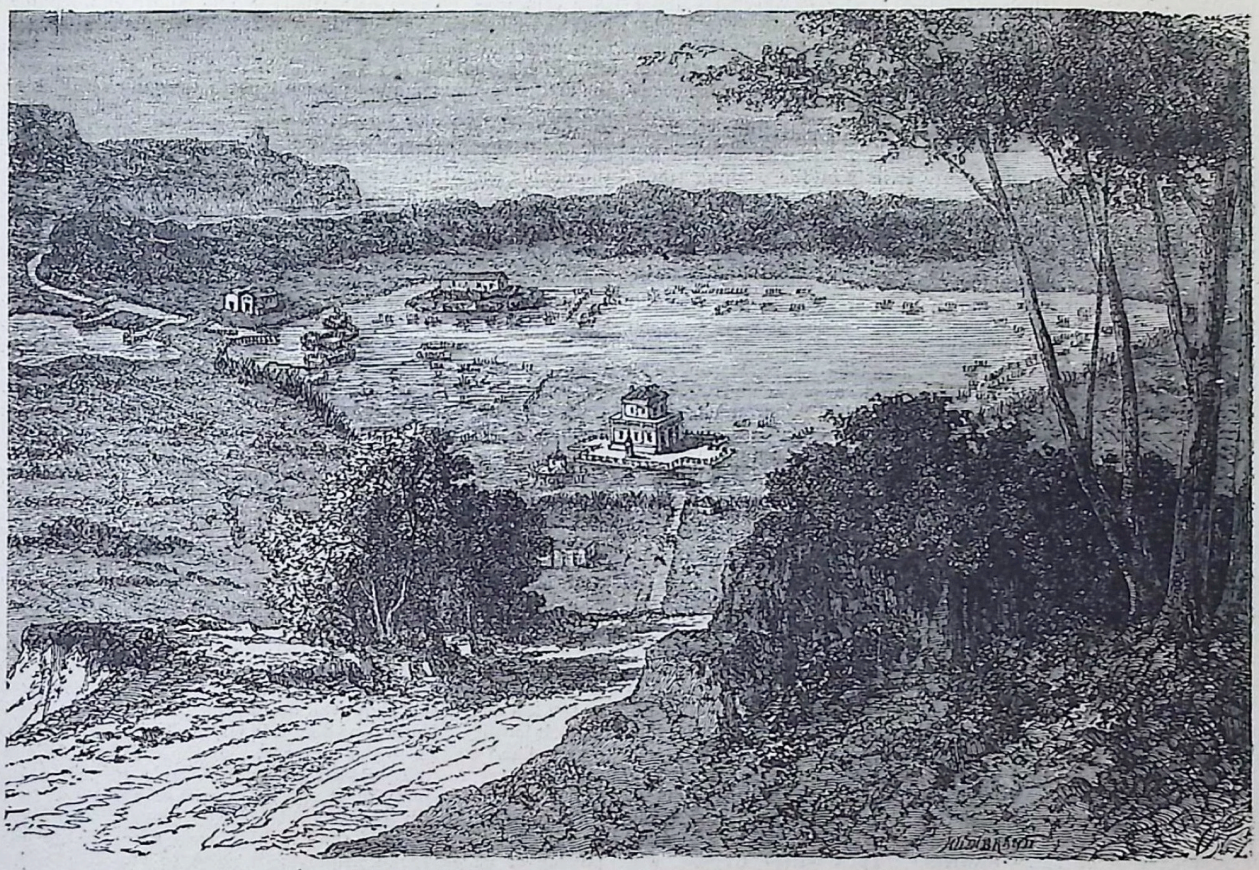
On many parts of the Continent, and particularly in Italy,

large salt-water lakes have been made, or are utilised, for the purposes of pisciculture. These works are, for the most part, the remains and the result of ancient industry. The singular lagune at Comacchio, on the Adriatic, is a peculiar instance of what art can do to assist nature in this respect. Originally the spot was a marsh, intersected by rivulets; at the outlet of these rivulets small islands, half submerged, lay close upon the coast. These rivulets were collected into a canal, the shallow pools made into one large lagune, the islands connected and raised, by means of wickerwork, etc., which made a labyrinth, at every outlet of which certain traps were set. The waters of the canal were turned into this lagune. The fish from the sea enter from the traps into the brackish water to spawn, but cannot return; and vast quantities of eels, mullets, and other fish are thus captured, a large stock always being kept up in the lagune.

of every fish or marine creature that can take it, whilst vast numbers perish from other circumstances; and were it not from the fact that each female oyster is said to give forth yearly from one to two millions of young, the stock, under the calls that are made upon it by man, must rapidly diminish.

When they wish to obtain oysters at Lake Fusaro, they either break them off the stones with hooks, or pull up the stakes or fagots, and detach such as they require with their hands.

"Dr. Kemmerer, of Ré, covers a number of tiles with a coating of a kind of mastic, brittle enough to enable him to detach the small oysters from it. When this coating is well covered with seed, he gets it off all in one piece, which he carries to the place where the seed is to grow. The same tile he coats a second time, and so on as long as the seed will deposit upon it.



GENERAL VIEW OF THE OYSTER PARCS IN LAKE FUSARO.

The Lucrine lake is another specimen of what can be done with oysters; but the salt lake of Fusaro is a more singular instance still. This lake, which is situated between the Lucrine lake, the ruins of Cumæ, and the point of Missene, was originally an extinct volcano, and at times, even now, the sulphurous exhalations penetrate the waters. About forty years ago the entire stock of oysters in the lake was killed from this cause, and the lake had to be re-stocked. The bottom is muddy, and is dotted over with large stones or fragments of rocks, to which the oysters may attach themselves; and round about these stones large stakes, which project above the water, are stuck into the soil—not so tightly, however, but that they can be withdrawn. From these stakes to others extend lines or cords, and from these cords, at intervals, are suspended fagots, to and within which the spawn of the oyster, when first hatched, can attach and ensconce itself until safe from any outward danger (Fig. 30). The use of these fagots and stakes is important, as when the young of the oyster is first hatched, it scatters in all directions, until it finds something to which it can safely attach itself. Meantime it is the prey

In short, wherever the violence of the currents and the stability of the bottom do not present irresistible obstacles, the cultivation of oysters has become a lucrative business."—*Galignani.*

The natural oyster fisheries of Cancale, once the most important in France, are, says Mr. Cholmondeley Pennell, still declining. They had risen to great importance by being left alone during the war between France and England in 1800 to 1815. In some places they had accumulated to a depth of more than a yard, and the annual catch immediately quadrupled and went on steadily increasing until 1847, when its maximum 71,000,000 of oysters was reached. The stock was thought inexhaustible, dredgers increased, and the natural consequence, its entire depletion, took place. At Granville the same results have followed from like causes. There are no artificial breeding-parks at either place.

Mr. Pennell considers the French principle of dividing the coast into districts, for the purposes of oyster-fishing, to be an excellent one, as it aims at giving each man in the district an interest in the prosperity of the fisheries, and also prevents a sudden descent of great numbers of men from different parts,

who would in a few weeks, or even days, indiscriminately clear out the oysters upon any bed where there might happen to be a good fall of spat, thus not only impoverishing the fishery, but also depriving the local dredgerman of the advantage which they might fairly expect to reap from what is after all often the result of their own labour. The principle, therefore, is excellent; it is an attempt at an approximation to the co-operative system; but, practically, the districts are so large, and the interests of each person consequently so small, that it fails in its most important object.

The American oyster industry (Chesapeake) is enormous. "It is impossible," says Genio C. Scott, "to arrive at an appropriate estimate of all which are 'canned' for the interior trade, and those sold in the shell for consumption in the Atlantic States; but of the trade from Virginia to Massachusetts, it is computed by the largest dealers in the industry that about 50,000,000 bushels are annually sold at 50 cents per bushel (25,000,000 dols.). But the following, copied from the Baltimore report of the industry in that single city for one year (1868), may give some idea of the importance of this crustaceous bivalve:—

"The trade in oysters has been in fair activity throughout the year. The number of houses prosecuting it now reaches about 73, of which some 40 are strictly in the packing trade. The hands employed equal probably 5,000 of both sexes in the various departments of shucking, packing, peeling, preserving, etc. Six to eight million bushels of oysters are consumed, one-third of which are packed raw, and the balance hermetically sealed. The cans required for these reach about 3,000,000 to 4,000,000, of half to one gallon each, and require say 300,000 cases to pack them. The balance of the oysters — some 4,000,000 bushels, are put up in hermetically sealed cans of 1, 2, and 3 lb. each, of which, during the active season, some 80,000 to 100,000 cans are daily packed, so that some 12,000,000 to 16,000,000 of cans are required for this trade annually. It is estimated that some 14,000,000 to 16,000,000 of dollars are invested in this interest in and around Baltimore, and that the annual product is worth some 6,000,000 to 7,000,000 dollars."

The number of vessels said to be engaged in that business on the Chesapeake is over 1,600, which gives employment to more than 6,000 persons.

It is encouraging to learn that America has been eminently successful in oyster-breeding. From Massachusetts to Florida, with more or less abundance, oyster-fisheries have been established, not only for dredging, but for cultivating. The result is, that this delicacy can be obtained at moderate charges, even in the interior towns and cities, such as St. Louis and Chicago; in fact, there is scarcely a respectable *table d'hôte* eastward of the Mississippi in whose bill of fare they are not to be found. "In the dominion where the winters are proverbially severe, they are equally abundant. New Brunswick, Nova Scotia, Prince Edward Island, and the estuary of the St. Lawrence, have long proved themselves prolific in this respect, corroborative of the fact that if you can get heat such as we annually have, it does not matter how severe the winter may prove for the abundant reproduction of these bivalves." Thus writes Ubique, who adds, "It has struck me that the American oyster may be of a different species from our own. The shape is not the same, and the flavour, I think, if possible, finer. If they are, could not the home-bred species be benefited by introducing the stranger? Experiment would soon elucidate this, for the American, if packed with the hollow side of the shell down, in solid masses, can be kept alive for months; in fact, I have been shown them thus stowed away in cellars, where they have been built in over ten weeks. What, then, would a voyage of ten days, under such circumstances, signify? The motion of the vessel might shake out some of their moisture (on which they subsist), but certainly not all."

The American oysters we have seen and eaten differ both from the French and English, having a nearly black *body*. They are of good flavour, and we are told can be purchased on the beds for £1 sterling a ton! Hitherto, several failures in their transit across the Atlantic have thrown a damp upon the speculation of their introduction into England, but doubtless ingenuity and perseverance will shortly devise some methods by which their perfect preservation will be secured. There is every hope of such a consummation, as small parcels almost invariably have arrived upon our shores in safety, as have likewise some few important shipments. The shape of the American oyster is, moreover, sharper, and more mussel-shaped than our natives.

If we might venture to make our own suggestions for the improvement of the oyster fisheries on our coasts, we would institute, in the first place, a general survey by the means of small steamers (tugs would be amply sufficient) carrying trawl nets and dredgers, so as to cover all the ground round our islands, and all beds when found, which doubtless very many would be, should be accurately marked upon a fish chart. We would have these public beds worked only every four or five years, and heavy penalties imposed for the possession and sale of spat, brood, and immature oysters of any description. We believe that if the dredgers were compelled to throw over all immature stock, taking the adult oysters would rather benefit than otherwise. These regulations should apply to all public beds as well as those newly discovered. At present, no sooner is a new bed found (and several have been accidentally met with within the last few years) than it is completely skinned, the dredgermen assembling from all parts carrying away adult oysters and brood indiscriminately—the former for immediate consumption, the latter for the preserves at the mouth of the Thames. We would have on board of these steamers a man thoroughly acquainted with the practical working of the dredge and trawl, and a superior officer of better education to keep a full record of all observations. By these means, which would be very inexpensive, we might hope to obtain fishing-grounds of great value. It is well known that fishermen, as at present constituted, will not waste their time or risk their nets by trying experiments, but, on the contrary, use their utmost speed to get to the fishing-ground of which they entertain the best opinion; the discoveries, as we have seen of late years, being entirely the result of chance, and not through any system of investigation. So wedded, indeed, are the fishermen to their own particular tracks, founded upon habit and the assured safety of the ground, that nothing would persuade them to risk their trawl or lose the whole expense of their trip in speculative trials. One great merit of this plan, we conceive, would be that of its economy; a tug-steamer with a crew of eight or ten men being fully sufficient for each section. The character of bottom and depths of water are already known and recorded in the maps of the Hydrographical Department, which information would, of course, be of great value in the investigation we propose. In beds and public fisheries there ought to be a constant inspection going on, and perhaps this could not be better entrusted to other than the coast-guard service, which, we believe, has but little of its old original work of looking after smugglers left to it to do. The information thus obtained should be transferred to the fish chart, and show the description of fish to be found in each locality. There is no doubt, in contradiction of all that is asserted and written to the contrary, that the supplies of deep-sea fish have really decreased, and considerably so during the last twenty years, in spite of the additional catching power, if we may so call it. In past times, the greater part of the vessels employed were vessels of ten to thirty tons, a very large proportion of which found employment close to our coasts, and brought their fish on shore every day. The vessels now principally employed are some sixty to seventy tons, handsomely built, and admirably equipped, which keep the sea for many weeks at a time, their fish being collected and brought to market by steam carriers; each of these vessels, while employing only an additional average crew of 50 per cent., having at least sixty times the average catching power, all circumstances being taken into account.

OYSTER AXIOMS.

Oysters breed in salt water, on a clean bottom.

Oysters fatten in brackish water, on a muddy or marly bottom.

Oysters are fit to leave the breeding-beds when two years old.

Oysters remain in the fattening-beds from one to two years.

Breeding oysters do not fatten, except on such ground.

Fattening oysters do not breed where there is much mud.

The natural oyster-beds of the United Kingdom are nearly all exhausted, being free to all comers, the demand being enormous, and continually increasing: the fishermen have dredged them bare.

Private breeding-beds are an actual necessity.

There is a demand for 100,000 acres of breeding-beds.

PATENTS AND PATENT LAW.—VI.

By a Barrister.

LEGAL PROCEDURE WITH REFERENCE TO PATENTS.

The proceeding in connection with patents most familiar to the lawyer, and with which patentees are most frequently concerned, is a suit for an injunction or for damages, or both, directed against infringers of a patent. In our last paper we dealt fully with the general question of infringement, so that we may here confine ourselves exclusively to procedure, which it is well every one interested in patent litigation should understand.

Most of our readers, probably, have heard of the proposed fusion of law and equity, a suggested reform in our law arising out of the monstrous injustice inflicted upon suitors by putting them first of all to the expense of a Chancery suit, and then turning them round to bring an action at law because the Court of Chancery was not invested with the power of awarding damages as a jury may do at common law. Some eminent lawyers, in their capacity of members of the House of Commons, addressed themselves to this grievance, without waiting for the larger reform which is inevitable. The late Sir John Rolt, a Lord Justice of Appeal in Chancery, and Lord Cairns, have passed Acts for the purpose of giving suitors complete redress in equity. The Act passed by Sir John Rolt says that in all cases in which any relief or remedy within the jurisdiction of the Court is or shall be sought in any cause or matter, every question of law or fact cognisable in a court of Common Law, on the determination of which the title to such relief or remedy depends, shall be determined by the same Court. This act was passed after Lord Cairns's, which more particularly affects patent suits.

Before Lord Cairns's Act (21 and 22 Vict., c. 27) damages could only be obtained at law, and where a plaintiff, in a case in the nature of a patent suit, prayed for an account, but afterwards desired to proceed at law for damages, he was not allowed to do so, except upon the terms of waiving his claim for an account. By the second section of the Act it was enacted that where the Court of Chancery has jurisdiction to entertain an application for an injunction against the commission or continuance of any wrongful act, it shall be lawful for the same Court, if it shall think fit, to award damages to the party injured, either in addition to or in substitution for such injunction. In the case of Betts against Neilson, Lord Chelmsford said that the object of this enactment was to empower Courts of Equity to deal with the question of damages instead of having to send parties for this relief to the Courts of Law. "There is nothing in the Act," he added, "to prohibit the court from awarding damages as well as decreeing an account. And the Courts of Equity having cases of this description entirely in their own hands, are able to administer full relief, which upon many occasions would not be obtained without both an account and an inquiry as to damages. The account and the inquiry as to damages have each of them a different object; one is to ascertain what loss the plaintiff has sustained; the other, what profit the defendant has acquired by the infringement of the patent. It might be that the party infringing had sold the patented article at an under-price, so that the amount of his profit would be no measure of the plaintiff's loss. And even in cases where there has been no such underselling, the plaintiff may have sustained damage far beyond what the gains of the defendant would compensate." It is then observed that in an earlier case for infringement of a patent, Lord Westbury, after directing an account, said, "That will be the whole of the decree unless the plaintiff prefers, instead of an account, to have liberty to bring an action at law for damages, which he may take in lieu of an account; if not, I direct an account as prayed." Lord Chelmsford comments upon this:—"But by his decree his lordship not only ordered an account of the profits made by the defendant by the making, use, and exercise of the plaintiff's invention, but also 'of such other compensation as is fit to be awarded to the plaintiff in respect of such making, use, and exercise.' It was suggested by counsel that the decree in this form was probably the result of an agreement between the parties, the defendant preferring to have the damages assessed by the Court instead of at law; but this will not explain away the fact of the decree being both for account and for damages, which shows that there is nothing irregular and improper in giving a plaintiff both these means of relief. It is so obvious to me that in many cases the account alone, or damages alone, will not satisfy the entire equity of a plaintiff in these cases, that there being nothing against principle, nor contrary to the enactment of the statute in granting the double relief; I shall hold the Vice-Chancellor's decree to be right in this respect."

We have quoted at some length from this judgment, because it is the most recent exposition by a high authority of the powers possessed by the Court of Chancery in giving relief to patentees who have suffered by acts of piracy. It will be observed, however, that whilst reference is made to damages nothing is said as to procedure by injunction. Suitors frequently elect to proceed at common law to recover damages whilst prosecuting their suit for an infringement, the old common law mode of trial being still in favour; and it has been expressly decided that in a suit for an injunction and an account the plaintiff may move to proceed with an action at law to try the right without previously moving for an injunction. The affidavit, however, on which such a motion is made must pledge the plaintiff's belief as to his title and the infringement of the patent right.

A suit being instituted for the purpose of restraining infringement by means of an injunction, the Court allows, at its discretion, discovery, which it need hardly be said is sometimes essential to enable a plaintiff to obtain redress. The Court, however, will not grant discovery unless satisfied that it may show or tend to show the fact of infringement. The defendant may, accordingly, though he denies infringement, be required to set out the names and addresses of his customers; or of persons from whom he has received sums of money as royalties in respect of goods manufactured by such persons in infringement of the plaintiff's right, though such persons may reside abroad; or to give particulars of the articles or machines manufactured, used, or sold by him, together with the price of the articles, the profits made on the sales, and other particulars. He may also be required to disclose whether he uses in his process the materials mentioned in the plaintiff's specification, whether he adds anything else, and whether such additions (if any) make any difference in the process; but he is not bound to disclose the nature and quantities of the additions. From the disclosures made under the discovery a plaintiff will frequently ascertain whether it is worth his while to proceed with his suit.

Supposing that he does proceed, the important question arises under what circumstances he will be entitled to an injunction. The ordinary rule of the Court of Chancery is that the legal validity of a patent must, in the first instance, be established, or that it must have been undisputed for a considerable number of years. But cases may arise in which the court will depart from this rule, as, for example, where the conduct of the defendant is open to suspicion, or where he has delayed unaccountably to take steps to oppose the suit. Having taken out a patent, the patentee may naturally consider that he has a right against any one using a similar invention. But it is quite open to a defendant to set up prior user, or show that the subject-matter of the invention is not the subject of a patent. This latter objection was taken in the case of a patent for improvements in ladies' veils, the same thing as the plaintiff claimed a patent right to do being proved to have been done repeatedly. It is always open to a defendant to prevent a plaintiff obtaining an injunction upon any grounds upon which the validity of the patent rests, and this he does by giving particulars of his objections, which particulars should be very carefully framed, as he will be confined within them on the trial. To give an example. In a suit to restrain the infringement of a patent for improvements in the construction of carriages, the alleged invention consisted of a particular mode of opening and closing the heads of carriages. Particulars of objections, which stated that head-joints similar to those used in the plaintiff's alleged invention had been, before the date of the patent, commonly used *by carriage-builders generally throughout Great Britain*, and that head-joints, similar to those described in the specification, had been actuated in their motions in the way described, before the date of the patent, *by various carriage-builders in or near London, Liverpool, Manchester, and Southampton, and various other of the principal towns of Great Britain*, were held insufficient. Vice-Chancellor Wood said that he should be disposed to tie the defendants down to specify the sort of carriage in which the alleged prior user took place, if he could not give the name of the manufacturer.

The courts are not at all strict in curtailing the right of objection of alleged infringers. A defendant in a suit for an injunction has been held entitled to dispute the validity of the patent, although the plaintiff has obtained a judgment at law against another person establishing its validity; but until he has proved its invalidity, he will be restrained from infringing it. Lord Romilly pointed out, in one of the numerous suits brought by the late Mr. Bovill, that it would be unjust, because one person has been unable to prove that the discovery was not new, to prevent another from doing so, and to bind him by a proceeding over which he had no control, and of which he knew nothing. His lordship added, "The consequence is, that in almost every case the patentee has to establish his case from the beginning against any fresh person who chooses to impugn the patent, and contest its validity." But, for the comfort of patentees, let us continue to follow this learned judge's remarks. "At the same time the law properly attaches to a patentee, who has established the validity of his patent, rights superior to those which belong to a patentee who has not done so. The former stands on a different footing, and though the patent may be contested by fresh persons, he will receive protection until the invalidity of it is shown. The distinction hitherto made by the Courts of Equity has been this: where the validity of the patent has not been the subject of any legal proceedings, that the patentee must prove its validity before a jury, before the Court of Equity will protect him; but having once established its validity, then the Court of Equity will protect him against any other person, until that person proves its invalidity."

It should perhaps be added here, though we confess the proposition strikes us as self-evident, that a plaintiff cannot recover damages by a suit in equity where it is practically impossible for him, at the time of filing his bill, to obtain an injunction to restrain the wrong complained of. A plaintiff filed a bill on the 8th of January, which prayed for an injunction to restrain the infringement of a certain patent and for damages. The patent expired on the 13th of January, and it was decided that as it was practically impossible for the plaintiff to obtain an injunction before the expiration of the patent, it was not a fit case for the interference of a Court of Equity.

Then arises the question what it is incumbent on the plaintiff to prove. Here again we are indebted to the enterprising Mr. Betts for information. Mr. Betts had manufactories for making capsules in France as well as in England, and the defendant in the suit suggested that the capsule used in the case of the alleged infringement might have been purchased at one of Betts's foreign manufactories. Lord Hatherley said—"I apprehend that the onus being on the plaintiff to show, not merely that the thing made is his own patented article, but that it has been unlawfully sold, he must be prepared to swear distinctly that it is not manufactured by him or his agent." And his lordship put the supposititious case of a man having three houses of manufacture, one in the north of England, one in the west of England, and one in London. "I cannot doubt," he said, "that it would be his duty, in making out his case before a jury, to prove not only that the article was of the same description as the patented articles, but that it was not made by himself; and for that purpose he would have to call as witnesses persons who had the control of his houses in the north and west as well as in London, to show that the article was not made by them."

There may be cases, however, in which the burden of proof is shifted. In a case very well known to patent lawyers, Penn *v.* Jack, it was laid down by a Vice-Chancellor that the onus of proving a particular alleged case of prior user rested upon the defendant. And where the defendant adduces such evidence, the plaintiff is allowed to bring forward evidence to rebut that of the defendant.

We have spoken of the remedies by injunction, or decrees for accounts and damages, for which latter an action at law may be brought as well as a suit in equity. To these measures of redress we may add that the machines shown to be an infringement of a patent may be ordered by the Court of Chancery to be destroyed. But this order will not be made as a matter of course in all cases. If it stop short of this extreme measure, it will, however, order them to be marked in such a way as to prevent their being used hereafter so as to continue the infringement. In the particular case which illustrates this point, the Vice-Chancellor said that, the patent being for a combination, the defendant might still use for other purposes the several parts of his machines.

And, lastly, a patent right may be slandered so as to give a right of action to the patentee in the nature of an action for slander of title. For instance, certain proprietors of a patent spooling machine brought an action against another proprietor of a patent spooling machine, for falsely and maliciously writing and saying to various persons in treaty with the plaintiffs for the purchase of their spooling machines, that the plaintiff's patent was an infringement of the defendant's, the defendant claiming royalties for their use, and threatening legal proceedings if these royalties were not paid, in consequence of which the plaintiffs lost the sale of their machines. The plaintiffs were defeated in this instance, as no intent *malâ fide* was proved; but Mr. Justice Blackburn said, "If the plaintiff had given evidence on which the jury might properly find that the defendant made the communication to the intending purchasers *malâ fide*, and without any intention to institute legal proceedings at all against the purchasers, so that it was not a step taken in support of his real or fancied right against the purchasers, but entirely out of malice against the plaintiffs," and knowing certainly that his claim was utterly without foundation, "we are inclined to think that it would have been proper to leave that evidence to the jury in support of the plaintiff's allegation that the defendant's letter was false and malicious." So that any warning given by a patentee to the purchasers or intending purchasers of the inventions of an alleged infringement must be *bonâ fide*, and with intent to assert a *bonâ fide* claim of right.

CONCLUSIONS.

It will have been seen that, although a great number of patent cases have come before the courts, the subject of patent law is not elaborate. The question of its reform is important, because it is difficult to see why inventors should be caused so much trouble and expense in procuring protection. The Society of Patent Agents, in a set of resolutions, have expressed their objections to the existing state of things. The chief defects of the patent laws are said to have arisen from a want of appreciation of the personal *right* of inventors to the sole use of their inventions, and the remark is made that "the true aim of legislation is to harmonise this personal right with the interests of the State." That is a vague sentence which it is difficult to understand. The interest of the State is to obtain as speedily as possible the benefit of inventions untrammelled by any personal right at all, and the only way to harmonise the personal right and the interest of the State seems to us to make them meet each other half-way as they do at present, the inventor obtaining the exclusive benefit of his invention for a certain period, and after that the State becoming the possessor. In the next place it is suggested that no mere importers of foreign inventions should be entitled to patents, and that every grant should be for a fixed period of twenty-one years, without the privilege of prolongation. As to expense, it is suggested that a fee of £10 for the entire term would be amply sufficient to secure an efficient administration of a simple patent system. The present cost of a patent is £175. Another resolution is that patents should be granted at the risk of applicants, without any official supervision of the specification or preliminary investigation of the merits of the invention. The only objection to this is that it might tend to check the spread of small discoveries which ought not properly to be subjects of a patent. An indiscriminate grant of protection to inventions would appear to us to have a mischievous tendency. Lastly, it is suggested that the rights of patentees should be determined by a competent tribunal, excluding all technical objections to the validity of the patent, and that jurors and expert witnesses should be dispensed with in patent suits. We have already expressed an opinion in favour of the first part of this suggestion, and in more than one case to which we have had occasion to refer we have seen the direst confusion arising out of the conflicting evidence of expert or scientific witnesses, so that the entire suggestion is based on common sense. It is, indeed, monstrous that patent law should have become so much of a science. It might be made very simple, and we shall have attained a useful object if, by the plain statement which we have put forward in these papers, we have made intelligible the existing state of the law and practice, and prepared any of our readers to understand and take part in the reforms which we trust are now pending.

SHIP-BUILDING.—XXIII.

BY W. H. WHITE,
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THE OPERATIONS OF SHIP-BUILDING.

Up to this point our aim has been to illustrate and describe the arrangements and combinations of the component parts in the *finished* structures of various classes of ships; now we propose to sketch the *order* in which the actual work of building ships is conducted, without, however, attempting to give details of the various operations.

Ships are usually built on *slip-ways*, sloping down to the water, and as the weights to be carried by these slip-ways are very great, care has to be taken to secure a good foundation. Upon the slips transverse piles of timber, termed "blocks," are erected at intervals of five or six feet, and are secured in place by struts, shores, etc. The upper surfaces of the blocks usually lie in an inclined plane, the slope of which towards the water is about ⅝ inch to a foot, and upon the blocks the keel of the ship is laid. In this common arrangement, therefore, the ship is built, *end-on* to the water, into which she is to be launched when completed, and the stern is generally, although not always, at the lower end of the slip. Cases have occurred, however, in which the lines of blocks have been laid parallel to the edge of the water, and the ships built *broadside-on*, so that they have had to be launched side-ways; the *Great Eastern* was so constructed at Millwall. It is not uncommon, also, to find regular slip-ways dispensed with in building small merchant ships, and recourse had to temporary and less costly arrangements. Every visitor to seaport towns must have observed instances in point, where small ships have been constructed on wharfs or quays, or in other places not specially prepared for the purpose.

Graving or dry docks have, of late years, been made use of for building many heavy ships, especially iron-clads. Such docks are, of course, very costly constructions as compared with slip-ways; but when they are available for the purpose, they offer much greater facilities for carrying on the work of building; and instead of launching vessels when completed, it is simply necessary to float them out. It is an interesting fact that quite a century ago, this practice of building in dock was tried in France, mainly with the intention of doing away with the severe strains incidental to launching ships from slip-ways, which strains were then regarded by many persons as the principal causes of the excessive hogging common in the ill-built wood ships of the period. After trial, however, it was found that this opinion was inaccurate, the ships built in dock having hogged very nearly as much as those built on slips, after they were afloat. The modern resumption of this practice is, as we have said, mainly based on considerations of convenience, and in illustration of this statement a brief notice of the plans adopted in the royal dockyards at Chatham and Portsmouth will not be out of place.

The blocks upon which the ship is to be built are laid at the centre of the floor, or bottom, of the dock. Along the sides of the dock, lines of railway are laid, upon which travelling steam-cranes are mounted, and by this means the materials brought to the dock-side can be readily placed in any position desired. Moreover, as the dock is excavated below the ground level, a very large part of the weights have simply to be lowered into place, only those connected with the upper works having to be raised. As compared with what has to be done in raising the weights of a ship built on a slip, even when the best appliances are provided, this is no small advantage; and it is of more importance when armour-plates, each weighing many tons, have to be wrought into the structure. Besides this, if desired, the hull of the largest and most heavily armoured ship can be completed with perfect safety in dock, before she is floated; whereas a similar ship built on a slip would almost certainly require to be launched before her armour was completed, and it would be advantageous in every respect to put her into a dry dock after launching, in order to complete the work. These and other advantages render it preferable to build such ships in docks, and enable the work to be done more quickly as well as more economically. One or two large private ship-building firms have also adopted this practice for iron-clad ships, but in most cases the dock accommodation is too limited to admit of its use.

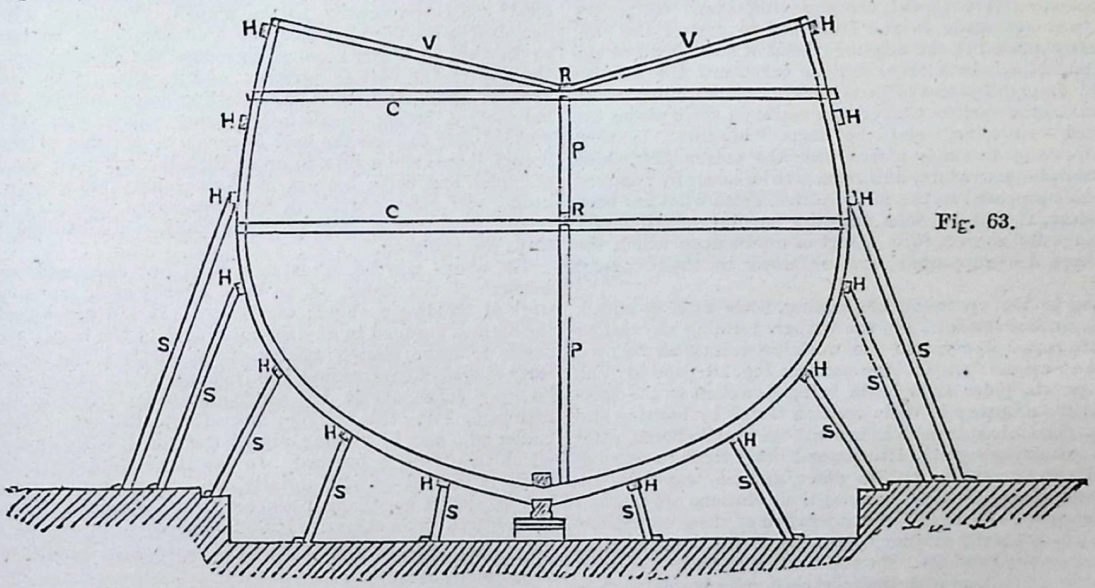


Fig. 63.

Space will not permit us to refer to the general arrangement of the workshops, plant, etc. etc., of ship-yards, although this is an important and interesting branch of our subject. We must at once pass on to notice the leading features in the ordinary method of proceeding with the construction of wood ships. For convenience, we will suppose the system of framing adopted to be that illustrated by Figs. 14—18, page 81, Vol. III.

The keel is first prepared and fixed in position on the blocks, and as soon as may be convenient the stem and stern posts are also put in place and secured. Next in order comes the "crossing of the floors"—*i.e.*, putting them into place, fitting them into their seating on the keel, dowelling them, etc. It is usual to put together each floor and its corresponding first-futtocks, as well as each pair of filling-floors, before they are crossed; and from what was previously said the reason will be obvious. This is really the first stage in the operation of "framing" a wood ship; it is usually begun amidships, and gradually carried forward and aft. While this work is proceeding, the deadwood, stemson, and other strengthenings near the extremities are prepared and fixed in place.

To make sure that the floors and filling floors are in their

correct positions transversely, a line or batten is stretched from some point in the middle-line of the keel to the corresponding heads or sirmarks on opposite sides, and the two measurements must, of course, be equal when the timbers are in place; this operation is termed "horning," and is applied in many other cases. To ensure the correct "stand" of the timbers in relation to the keel, large squares or bevels supplied from the mould-loft are often used. To prevent any chance of departure from symmetry in relation to the middle line, a batten is stretched across from side to side, and being fixed at corresponding heads or sirmarks, a spirit-level is laid upon its edge, or a plumb-bob is dropped from its middle point, which should, of course, be exactly over the middle line of the keel. These simple tests are described here because they are again and again applied in framing both wood and iron ships to ensure the symmetry desired, and to keep the frames in their correct positions.

When the adjustment has been carried out, the timbers are secured by means of a longitudinal "harpin" or "ribband," wrought along under the floors and secured to them, as well as supported by shores heeled upon the slip-way. To shorten our explanatory remarks as much as possible, we have in Fig. 63 given a rough sketch, showing a transverse sectional view of a ship in frame. H, H, H, represent harpins, and S, S, shores. These harpins, be it observed, are most important temporary securities, and are made to run from end to end of the slip, being usually placed in the neighbourhood of some head or sirmark. Amidships, where there is little curvature, the harpins are formed simply of pieces of fir of square section, upon which the stations of the various timbers are marked; these pieces are often styled "ribbands," and the term "harpins" is then applied especially to those pieces near the extremities which have considerable curvature, and require to be carefully trimmed to the moulds prepared in the mould-loft. From what has been said, therefore, it will be seen that the harpins and ribbands, when in place and shored, form a sort of cradle upon which the frame-timbers are supported and retained in their correct positions.

Reverting to the operation of framing, little need be added. In the case under consideration, the timbers forming the various futtocks are raised singly, and the work progresses as follows. A few of the "second futtock" timbers (see Fig. 16, page 81, Vol. III.), are put in place, their butts being dowelled to the floor-heads, and the accuracy of their position tested by horning and levelling. Then a harpin is fixed beneath them and shored, after which the remaining second futtocks, and other timbers crossing the harpin, can be rapidly put in place, and no trouble is required to test their positions, because their stations are marked upon the harpins. By means of a repetition of these operations the framing is gradually extended upwards, and at the same time it is carried forward and aft. In the cant-bodies the plan followed is almost identical with that sketched, only special care is needed in fixing the lower cant-timbers at their proper heights and "flights," or deviations from the transverse lines. When advanced thus far, further securities are provided for the frame by means of "cross-spalls" (C, C, in Fig. 63), stretching across near the heights to which the decks will be brought, and with these cross-spalls are associated longitudinal ribbands (shown in section by R, R), diagonal struts (such as V, V), vertical stanchions (P, P), and other means of preventing change of form in the framing during the subsequent operations. At this stage a ship is said to be "in frame," and formerly our wood ships of war were not uncommonly left in this condition for considerable periods in order to season the timbers.

Beyond this stage the order in which the work is conducted differs very considerably under various circumstances, and it would be idle for us to pretend to lay down a rule, or to attempt within the space at our disposal to describe in detail the various operations. It may be taken for granted that commonly the work of preparing and fixing the keelson will have been completed when the ship is framed; also that considerable progress will have been made in preparing the deck-beams and other pieces, as well as fitting the fillings between the frames. Before planking can be begun, however, the frame must be faired and "dubbed-out." The outer surfaces of the timbers are carefully trimmed to the form of the moulds provided, and are consequently very nearly fair when put in place on the harpins; but the inner surfaces are not so carefully treated, and require more fairing after the framing is complete. When this is done the iron riders can be fitted and temporarily secured, and the work of fixing the skin-planking can be commenced; while at an early period the preparation and fixing of shelf-pieces, ekings, hooks, etc., can be taken in hand.

Respecting the planking, it can only be said that the wales are usually commenced about the same time as the garboard-strakes, the operations of planking up from the garboards and down from the wales being proceeded with simultaneously, and the shutting-in strakes being fitted in some intermediate position, while the planking from the wales to the gunwale is worked upon independently. All such matters depend, however, upon the circumstances under which ships are built, and the degree of urgency with which they are pressed forward. So also do the steps taken in carrying on the inside work—framing the decks, working the clamps, ceiling, binding strakes, etc. In the Government service it is customary to carry these on at as early a period as possible after the outside planking has been begun, so that as many of the through-fastenings as possible may be made to serve as fastenings for the planking also, and no delay be caused in "squaring-off." These are matters which have already been considered in previous papers.

As the planking is proceeded with the harpins and ribbands are, of course, removed, and the shores are then placed under cleats fixed temporarily to the planks. Similarly, when the deck-beams are fixed in place, the cross-spalls can be removed, as they are no longer required to secure the frames, and are in the way of the further progress of the work on the decks—such as fitting the water-ways, letting-down carlings, framing hatch-ways, laying the deck-flat, fixing pillars, etc. It is important also to clear the hold as much as possible of the temporary shores and struts, in order that the work on the fitting of engine and boiler-bearers, hold-stanchions, transverse bulk-heads, and other partitions, for store-rooms, etc., may be proceeded with, which works are generally well-advanced before ships are launched.

The above may be taken as a brief but clear and succinct account of the order, as we have already said, in which the work of building a ship is carried on. It will prove useful to the artisan engaged in any special branch of the trade, who may desire to make himself master of the method adopted in the early stages of constructing the framework of a vessel on which he may subsequently be employed in making the interior fittings or fixing the rigging; and also to the non-professional reader who may be visiting any of the yards, large or small, in which this trade is pursued. In the large shipping ports the work is carried on with activity and energy on a large scale; but in almost every small seaport town, especially in the west of England, wood ships are built for employment in the coasting trade, and in the fruit trade with the Mediterranean, Levant, etc.

MINING AND QUARRYING.—XXXI.

BY GEORGE GLADSTONE, F.C.S.

GOLD.

DISTRIBUTION—NATIVE GOLD—ASSAYING—AMALGAMATION—SEPARATION FROM SILVER—PROPERTIES—USES—MONETARY—STANDARD GOLD—JEWELLERS' GOLD—GOLD LEAF—GILDING—ELECTRO-GILDING—GOLD WASH—COLOURING PROPERTIES.

GOLD is very generally diffused over the surface of the globe; indeed, there are few countries of any extent which have not, at some period or other of their history, furnished sufficient gold to remunerate the explorer. As, however, it is almost always found in the metallic state, and is so easily recognised and distinguished from any other metal, those countries of the Old World which have been long and thickly inhabited, have long since yielded up their golden treasures to their former inhabitants.

At present, the United States of America contribute more than one-third of the total supply; and so do our colonies in Australia and New Zealand. The Russian empire supplies about an eighth; and the remainder is made up by a long list of smaller contributions. Europe, excluding Russia, figures in this list to the extent of about 1 per cent., almost all of which comes from the Austrian empire; though it is beyond

question that Spain, Italy, and Britain have in former times furnished considerable quantities.

More particularly now as to our own country. Grains of gold are now and then still found in Cornwall by the streamers for tin; in a limited area in the north of Scotland, gold washings fairly remunerate the labour expended; in North Wales systematic mining for auriferous quartz is conducted; and in Ireland a small fraction of gold in some of the pyrites of Wicklow adds to the commercial value of that mineral, as it is more than sufficient to cover the cost of separation.

We have already said that gold almost always occurs in the metallic or native state; nevertheless, pure gold is never met with in nature, it is always alloyed with silver. The proportion of the latter metal varies greatly, sometimes amounting to nearly two-fifths of the whole. The produce of Australia and New Zealand is remarkably pure, as it contains only about 3 per cent. of alloy, and is therefore considerably above the English standard. Neither California, nor any of the other countries of the world, supply gold which will on an average equal our standard. It is therefore necessary that every parcel of gold should be assayed before its market value can be arrived at.

Gold dust, the form in which the metal is usually found, is therefore melted and poured into ingot moulds; and each bar is then the subject of a separate assay. The plan officially adopted both here and in France is to take half a gramme, equal to 7·72 grains, of the gold bar, and cupel it with the addition of lead, and a quantity of silver estimated to be equal to three times the weight of the gold itself. The button thus produced is flattened out till it is about $\frac{3}{4}$th of an inch in diameter, annealed, and then rolled out into a riband of from $2\frac{1}{2}$ to 3 inches long; it is then annealed a second time, and rolled up by hand into a spiral form. The cornette, as this is called, is then put into a flask, and boiled in nitric acid, of 1·18 specific gravity, until nitrous fumes cease to be evolved. This acid is poured off, and the flask is then filled with acid of 1·28 specific gravity, in which the cornette is again boiled. By this time the whole of the silver has been dissolved out by the acid, and the gold has become spongy and very fragile. The whole of the acid must now be removed by careful washings in distilled water; the gold is then gently transferred into a crucible, in which it is heated just sufficiently to make the gold cohere, so that it can be handled without fear of loss, when it is removed to the balance and weighed.

Auriferous quartz is crushed under stamps on the spot where it is raised, and the gold separated from the matrix, usually by amalgamation with mercury, so as to save the carriage of useless material. If an estimate of the per-centage of gold in the quartz itself is desired, the average of a number of fairly-chosen samples should be taken; the quartz selected is reduced to a fine powder, and melted in a crucible with six or seven times its weight of litharge, and a little charcoal powder. The button of metal thus produced is then cupelled in the manner described in Article XXIX., on the assaying of silver.

When pyrites have to be assayed for gold, they are usually calcined first in a scorifier, until they cease to give off any sulphurous fumes; and then the roasted ore is treated in the same way as the auriferous quartz, except that some borax equal in weight to the ore is also added. In both cases, after cupellation, the silver must be separated by the action of nitric acid, before the final result in pure gold can be obtained.

A great variety of machines have been invented for the purpose of crushing and amalgamating the quartz and other auriferous rocks to the greatest advantage, but these are rather of interest to the people of California and other mining districts. The principle upon which the collection of gold by the agency of mercury is conducted may, however, be touched upon, as it is applicable to other purposes. The rock should be crushed or ground under water to an impalpable powder, and then washed down from the mill or stamps to the amalgamator. This is generally provided with a mechanical stirrer, by which the powder is worked up with the water into a pasty state. A quantity of mercury is then introduced, which must be more than sufficient to take up all the gold estimated to be present, and the stirring is kept up until the amalgamation is complete. The excess of mercury is forced out by pressure, and the soft cake of amalgam is transferred to a retort, to have the mercury distilled out of it. A very moderate heat is sufficient for the purpose, and one of the principal matters to attend to is the adoption of such an arrangement as shall effectually prevent the escape of any mercurial vapour, which, if permitted, would seriously affect the health of the workmen. The apparatus figured in the annexed drawing (Fig. 1) will answer the purpose. A B represents a round iron vessel made in two sections, which can be bolted together at the flanges; from the upper part of A, an iron pipe rises which is bent downwards, until it enters the receiver C. This is filled with water to a level slightly higher than the mouth of the pipe. The amalgam is placed in B, the upper segment then screwed down and well luted round the flange, so as to prevent the escape of any vapour, and a brazier with a lighted fire placed below the retort. The mercury, as it becomes volatilised, passes into the iron pipe, where it condenses and falls into the water contained in the receiver: as soon as the mercury ceases to come over, the operation is at an end, the fire is withdrawn, and when the retort has cooled, it is opened, and the gold taken out. The mercury is then available for another amalgamation.

Not only is silver so generally to be found in native gold, but many of the ores of silver, and hence also much of the silver money coined abroad, contain more or less gold. It is evident from what has gone before that the more valuable metal can be separated from the other by the agency of nitric acid; but in conducting this operation on a large scale, it is found more economical to substitute sulphuric for nitric acid. The metal is first granulated, by throwing it while melted into cold water; and then it is boiled up with sulphuric acid in iron tanks. The silver is thus completely dissolved, leaving the gold untouched, which is then allowed to settle to the bottom. The silver solution is then drawn off into other tanks, and the gold being collected is washed, and melted into bars. The whole of the silver is recovered by placing sheets of metallic copper in the solution; when the silver, having less affinity than the copper for the sulphuric element, crystallises out at the expense of the other metal, which in turn is converted into the sulphate.

Pure gold possesses the great advantage of not tarnishing on exposure to the air, and indeed it is altogether unaffected by almost the whole catalogue of chemical elements. It will combine with chlorine to form a salt, and it is soluble in a certain mixture of nitric and hydrochloric acids; but these are about the only exceptions beyond that of entering into alloys, and some double salts. It is remarkably heavy, the specific gravity being 19·3, is moderately soft, and highly ductile and malleable, so that it can be drawn into very fine wire, and beaten into very thin leaf.

Amongst its uses, that of a medium of exchange deserves first notice. Its cleanness and convenience specially recommend it for a metallic currency, but the pure metal would be too soft to stand the constant wear, and a standard alloy with copper is therefore adopted, containing 91·67 per cent. of pure gold, or 22 carats fine, the pure metal being reckoned as 24 carats. No uniform international standard of fineness has yet been agreed upon, so that the standard of the country must be taken into account in calculating the intrinsic value of foreign gold coin.

Still more uncertain is the fineness of the gold used by the jeweller. It is, in fact, alloyed in various proportions, either with silver or copper, according to the colour that may be desired. Thus, if a red gold is wanted, the relative proportions will be about 75 per cent. of gold to 25 per cent. of copper; and by substituting silver for copper in similar quantity, a greenish coloured gold will be produced. These, in the language of goldsmiths, will be 18-carat gold. For some purposes a still larger proportion of silver is employed.

On account of its great cost, gold can be used only sparingly except in special cases. Nevertheless, in consequence of its rich colour and its non-liability to tarnish on exposure to the influences of even the vitiated atmosphere of our large towns, it is the metal which above all others is used for decorative purposes. Few even of the poorest in our land cannot produce some article or other into the composition of which gold has not entered.

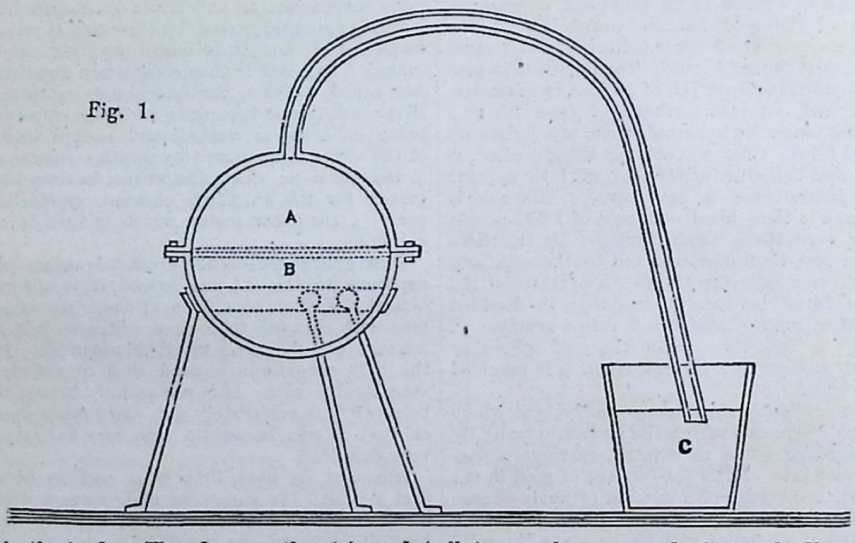
A necessary contributor to this result, however, is its great malleability. A single grain, the first cost of which is about twopence, can be beaten out into leaf which shall cover 75 square inches, though for ordinary purposes it is not carried to

this degree of fineness. A little gilding can therefore be enjoyed at a very moderate outlay. The mode in which gold-leaf is prepared is worth study, and then the various ways in which it may be employed will call for attention.

Gold-beating has for a long time been an important business in the neighbourhood of Clerkenwell; London indeed having always stood pre-eminent in this industry. Pure gold is softer and more malleable than any of its alloys, but leaf made from it is more tender and less economical in use than that made of an alloy containing a moderate proportion of either silver or copper. Which and what quantity of the cheaper metal shall be used depends partly on the question of colour: in either case the operation is the same.

The gold is first melted at a high temperature, and run into ingots of about two ounces in weight; these are afterwards rolled out between steel rollers into ribands of an inch and a half wide, and of such thickness that a strip ten feet in length shall weigh an ounce. The metal will have become more brittle under this operation, and must be annealed by heating it, before it can be further dealt with. It is then cut up into squares of an inch each way, and these are placed in a pile with a leaf of fine vellum or parchment paper between each, the bundle so made being called a "cutch," and then the actual beating commences, with a hammer of 17 lb. weight. After about twenty minutes the squares of gold will have spread out to about four times their original dimensions; and they are then taken out, cut into quarters, and made up into another pile, called a "shoder," the alternate leaves being made of gold-beaters' skin. The shoder is beaten with a lighter hammer for about two hours, until the gold has again expanded in like degree. These leaves are again quartered and carefully beaten a third time between goldbeaters' skin of the finest quality, with a still lighter hammer, which reduces them to the thinness customary in the trade. The edges are then trimmed, and the leaves transferred into the little books in which they are sold. 100 square feet of ordinary gold-leaf will weigh an ounce.

Fig. 1.



There are various ways of applying gold-leaf, dependent upon the material which has to be gilded, and the effect which is desired to be produced. In gilding cornices, looking-glass and picture-frames, etc., the solvent in the composition to which the leaf is made to adhere may be either water or oil; the latter is distinguished as oil-gilding, and though less used, has the advantage over the former of bearing cleaning better. The size used for the more ordinary process consists of a mixture of plumbago, red chalk, pipe clay, bullocks' blood, and suet; this is melted with some ordinary clear size, and laid evenly on the moulding with a fine brush. Before the gold-leaf is applied the size is moistened with a little water. If a dead surface is desired, the gold has only to be washed over with very thin clear size; but if bright, the gold is polished by being rubbed with an agate or steel burnisher.

In oil-gilding the size used is made of a mixture of boiled linseed oil and ochre. The gold-leaf is applied before the oil has become quite dry. The mode of laying it on, and the subsequent burnishing of the parts intended to be bright, are the same as in the other case.

The lettering or otherwise ornamenting book covers, whether of leather or cloth, is done by the pressure of a hot metal block corresponding to the intended device. A little isinglass or white of egg is first spread over the surface in the case of leather; the gold will adhere sufficiently to cloth without either. On the cover being taken out of the blocking-press the superfluous gold is brushed off.

The gilding of metals is done by a very different process. The principal application of gold in this way is in the manufacture of jewellery, ornaments, and household utensils, and the agency by which this is nearly always done now is electricity. A liquid solution of a gold-containing salt has to be prepared, the aurocyanide of potassium being used for the purpose. To make this the gold is dissolved in aqua regia (three parts of hydrochloric acid to one of nitric acid), which will produce the terchloride, and by digesting this with calcined magnesia the gold will be precipitated in the state of oxide. In this condition it can be dissolved in a solution of cyanide of potassium, forming the double cyanide above named. As, however, a battery must be at hand for the gilding process, the most convenient plan is to employ the same agency for dissolving the gold in the first instance. To do this it only requires that a plate of pure gold be placed in a bath of cyanide of potassium, and connected by a wire with the positive terminal of the battery, while a sheet of copper or iron, connected with the negative terminal, surrounded by a porous cell filled with the same liquid, is placed immediately opposite to the gold plate. The precious metal is allowed to dissolve until a gallon of the solution contains from one half to an ounce of gold; the precise strength most suitable is dependent to some extent upon the description of articles to be plated. These are commonly made of silver, copper, or some of the copper and zinc alloys described in Article XXII., which in point of colour bear so striking a resemblance to gold itself. Before being placed in the bath to be gilded they must be rendered perfectly free from both grease and oxide, or the gold will afterwards be apt to scale off. They are, therefore, first boiled in caustic alkali in order to saponify and render soluble all traces of grease, and afterwards dipped for a moment in pickle which consists of a mixture of nitric and sulphuric acids and water, and then plunged into distilled water. From this they are transferred to the gold solution, which is kept at a temperature of not less than 130° Fahrenheit, and in the course of a few minutes the articles immersed will be sufficiently gilded.

Trinkets are very frequently washed with gold, which is done by forming the metal into an amalgam with mercury. The two metals readily combine in this way on throwing small pieces of gold heated to redness into a bath of warm mercury, and the product is a soft yellowish mass. The metal to be gilded by this process is rubbed over first with a solution of mercuric nitrate, which not only serves to clean the metal, but also deposits a part of its mercury upon the surface; and this assists in securing the adhesion of the amalgam, which is afterwards applied with a brush. The articles have then to be exposed to a gentle heat to expel the mercury from the amalgam by volatilisation, when metallic gold will be left as a thin coating over the surface. It then presents a dull appearance, and has to be rubbed and burnished in order to produce a proper effect.

Except for the purpose of gilding, the few salts of gold that can possibly be made are little used. The chief exception to this lies in their use as a colouring material. The oxide, either alone or in combination with a tin salt, will produce, either in glass or enamel, a series of reds and purples of very great depth and brilliance, and is therefore largely employed by stained-glass manufacturers.

HOROLOGY.—I.

By A London Watchmaker.

WATCHES: THE ARRANGEMENT OF THEIR COMPONENT PARTS.

As we have already given in Vol. I., pp. 166, 190, and 253, of this work a general review of the history of clock and watch making, including descriptions of some of the fantastic uses of the art, it is now our purpose to investigate the present methods and principles according to which the portable timekeeper or "watch" is constructed; and in so doing we shall reject all questions of priority of invention of any particular parts, stating simply how, and in what manner, the average good watch of the present day is made; prefacing our statements, in all cases, with such general introductory observations as may be necessary for the better elucidation of the subject. We trust that we shall be able, in this manner, to present to the general reader a mirror in which he may see where improvements may be necessary, and how far the watchmaker is entitled to the claim that he makes of being ranked amongst the "scientific artists" of his time.

We shall observe, with as little digression as possible, the following order in treating of our subject:—

1. Arrangement of the various parts.
2. Construction of the same.
3. General notions of the lever escapement.
4. General notions of the chronometer escapement.
5. General notions of the duplex escapement.
6. General notions of the horizontal or cylinder escapement.
7. Methods of making and applying the pendulum spring, and of obtaining its isochronism.
8. Manipulation of compensation for errors due to variations in temperature.

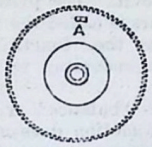


Fig. 3.—DRIVING-WHEEL SEEN FROM BELOW.

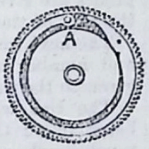


Fig. 3a.—DRIVING-WHEEL SEEN FROM ABOVE.

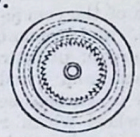


Fig. 7.—BODY SEEN FROM BELOW.

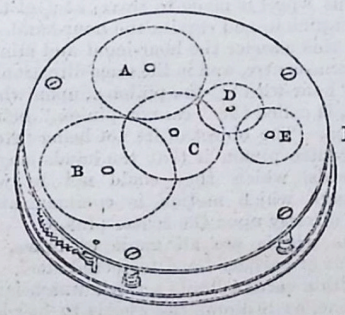


Fig. 1.—DRUM OR BARREL OF WATCH.

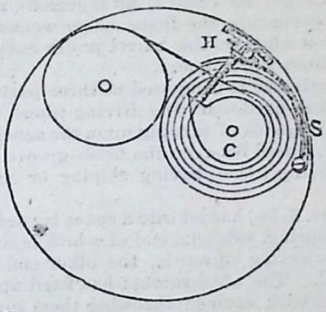


Fig. 4.—CYLINDER AND FUSEE WITHIN DRUM OR BARREL.

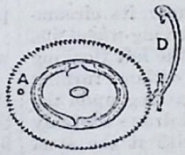


Fig. 6.—RATCHET WHEEL IN FUSEE AND DETENT.

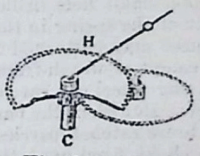


Fig. 5.—CENTRE WHEEL.

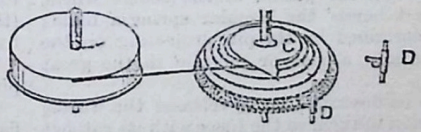


Fig. 2.—FUSEE AND CYLINDER.

ARRANGEMENT OF THE VARIOUS PARTS.

The first portable timekeepers made for carrying on the person having been egg-shaped, acquiring later a flattened spherical form, and taste and civilisation having demanded that time should be kept without such encumbrances as were these instruments to their users, they are now made as circular discs, nearly flat, and measuring about two inches in diameter, by half an inch in thickness; convenience has thus usurped the rights of economic and advantageous construction, for, had these been consulted, our best watches would now have assumed the shape of a gentleman's card-case or snuff-box, *i.e.*, rectangular, oblong, or of a dwarf spectacle-case, seeing that no corners are necessary. The reason of this will be explained in the consideration of construction of the parts.

The circular form having then been adopted, we have now to consider what our disc is to contain, our primary object being to convey to the sense of sight some certain indications by which the course of the march of hours may be exhibited.

This is effected by affixing hands or pointers to the ends of the spindles of certain wheels, which are made to travel at fixed relative speeds by means of cogs or teeth, by means of which one wheel cannot turn or make one rotation without giving a definite amount of regular motion to its neighbour—say for one turn of A, ten turns of B, or *vice versâ*.

The wheels themselves are fixed upon arbors or spindles, which are held in their relative positions by plates of brass which are screwed together. The object of these teethed wheels is twofold—namely, to transmit the power or force which is generated in a drum or barrel (Fig. 1), and by virtue of the varied number of their teeth or cogs to preserve the fixed ratio of speed necessary to cause the hands to revolve at the required pace.

The force is obtained by coiling round the spindle of A (Fig. 1), and inside the brass barrel a steel riband, called the mainspring, one end of which is pierced through and hooked on to a small protuberance in a solid steel cylinder fixed to this arbor, and the other end of which is fixed into the side of the barrel by a hook riveted into the thickness of the riband, and filed square to adjust itself into a mortise filed in the side of the barrel.

This steel riband, which is hardened and tempered, is somewhat coiled before placing it in the barrel, otherwise when bent, so as to enter the barrel, its tension would be so great as to cause each superposed coil to press so hardly upon the adjacent exterior one as to offer too great a resistance to its circular motion, and thus render the remaining force available for turning the barrel almost useless.

The spring has consequently a spiral shape, of a diameter about five times that of the barrel before it is placed in it.

The arbor is free to turn in the barrel, which in Swiss watches communicates its power direct to the centre wheel (C), which carries the minute-hand, but which in English watches transmits its force first to a fusee by means of a steel chain passing round either, and having its ends fixed by hooks in the opposite ends of these two cylinders.

The fusee is a conical cylinder, and has a groove cut in its surface to prevent the chain slipping (Fig. 2).

The barrel arbor has a ratchet let on to a square filed upon it at one end projecting outside the lower plate, upon which is a spring-click to prevent the arbor turning back when the spring is wound round the steel cylinder, which forms part of the arbor and is inside the barrel.

This steel cylinder is one-third the diameter of the barrel, to give the spring a sufficient leverage from the centre of the barrel, and to prevent breakage of the latter through being too sharply bent. Both ends of the spring are, in addition to this precaution, slightly softened from their tempered state.

In the Swiss (as in some of the modern English) watches the barrel has teeth upon its periphery, which gear into the pinion of the centre wheel, the barrel itself turning by the force of the spring, which is bent or coiled round the steel cylinder by a key adjusted to the end of the barrel arbor passing through the upper plate. This method has the disadvantage of giving greater power when the spring is tightly wound up than it does when half or more of its tension has been relaxed, by the gradual unwinding of its coils towards the outer part of the barrel.

To remedy this inequality, the fusee was introduced, by which the barrel delivers its force through a series of levers, growing longer as the power diminishes, to the pinion of the centre wheel; this is effected by the chain winding itself round the barrel off the conical and grooved fusee, drawing the chain first from the small diameter, and as it winds towards the other end of the barrel which is opposite, the larger diameter of the

fusee acting upon the centre of the fusee at points farther and farther distant from it as the mainspring power becomes less, and thus equalising the power.

It has been attempted to gain the same end by making the riband with a diminishing thickness towards the outer end; but this method has the disadvantage that the inner stronger coils carry the outer weaker ones all to the outside of the barrel at once, instead of allowing it to pass over coil by coil, and thus losing a great deal of power by the rubbing of one coil against another: the best method, therefore, of procuring a constant and equal force is found in making the barrel rather larger, and using a long spring, which, when adjusted for use, is never fully wound up, and is never quite relaxed, the middle coils only being used.

When a fusee is used, the spring is bent, or—as the common expression runs—the watch is "wound up," by a square on the fusee arbor, which, turning the fusee, draws the chain off the barrel, and so coils the spring tight and close, by drawing round its outer end. Now, as by using too much force and winding too far the chain or spring might be broken, an ingenious method has been devised for preventing the fusee being wound more than sufficient turns for storing in the barrel power enough to cause the watch to go about thirty hours.

The fusee with this appliance is composed of three parts—the arbor with the grooved cone fixed to it; the driving-wheel, placed lowest in sketch (Fig. 2), capable of turning upon the arbor; and a wheel, usually of steel, placed between the brass-grooved body of the fusee and the driving-wheel, having sloping or ratchet-cut teeth upon it.

The driving-wheel (Figs. 3, 3*a*) has let into a space turned in its upper surface a circular spring, into one end of which is screwed a short steel pin (A) projecting upwards, the other end being screwed fast to the wheel. The steel ratchet has fixed upon its upper surface two clicks with springs throwing them inwards, which clicks act upon a small brass ratchet screwed to the under surface of the body of the fusee.

This steel ratchet has a small hole drilled near its circumference, into which the pin of the spring in the driving-wheel fits. Thus the body of the fusee may be turned to the left (looking from the top of the movement or watch-frame) without turning either the ratchet or driving-wheel, its ratchet acting upon the clicks in the steel ratchet. But when the barrel draws the body round to the right, its brass ratchet carries with it the steel ratchet (by means of the clicks fixed upon the latter), and this draws the driving-wheel with it, by the pin in its spring. But the driving-wheel is held by the pinion of the centre wheel, therefore the ratchet first bends the circular spring a little; its circular motion is determined by the pin projecting on the lower side of the spring into a slot or mortise in the great wheel.

As the escapement (to be described later) releases the wheels and allows the centre pinion to turn, so the fusee with its ratchet and body turns to the right; the ratchet is prevented from returning by a click or detent, D (Fig. 2), pivoted between the upper and lower plates of the watch.

Thus the first portion of the power of the mainspring, when bent up, is expended in bending the circular spring in the driving-wheel, the ratchet at the same time being drawn a few teeth past the detent D; then, at whatever time the watch is again wound, this circular spring in unbending itself drives the great or driving-wheel during two or three minutes, or so long as the key is held on the fusee body arbor square, until it is released, although during winding no power is derived from the mainspring. This arrangement is called the "maintaining power," and has the effect of keeping the watch going while being wound.

The Swiss and English watches without fusee require no such contrivance, as the action of winding only tends to add power to the barrel, as its motion is not reversed, the spring being wound from its inner and not its outer end.

Fig. 4 shows H, a small piece of steel pivoted between two brass jambs fixed on to the lower side of the upper plate, and held away from it by the spring S, but which, when pressed to it by the rising of the chain on the fusee as the watch is wound, butts against the cap of steel, C, fixed on the top of the fusee-body, and so prevents the spring in the barrel being wound too far.

Besides affording the means of equalising the power of the spring, the fusee is useful in another way—namely, in multiplying the movement of the barrel; for as several of its diameters off which the chain winds are smaller than the uniform diameter of the barrel, four turns of the latter are sufficient to give five or six turns to the former; on the other hand, power is lost through friction, and the fusee, besides occupying a great deal of space in the watch, is costly; besides which, its use brings another fragile part, the chain, into the watch's construction, and its interior arrangements are an additional cause of expense in repairing the watch.

Wheel D (Fig. 1), called by watchmakers the "third wheel" (being the third from the fusee—the barrel, having no teeth, not being deemed a wheel), serves simply as a multiplier; wheel E (the "fourth wheel") makes one revolution in a minute, and in watches in which it is intended to show the seconds upon the dial, this wheel has a long pivot passing through the lower plate and dial, and carries the seconds-hand.

English watchmakers call the plate on the dial side of the watch the "lower plate," or "pillar plate," because brass pillars are riveted into it. The plate which is screwed on to the tops of these pillars is called the "upper or top plate."

The next wheel after the "fourth" varies in its appearance and number of teeth, according to the escapement which is given to the watch.

The last wheel or "balance" vibrates "to and fro," it being found that this motion does not accelerate as does the revolving fly, especially when governed by a "pendulum spring," so called by reason of the "balance" having been devised to imitate the motions of the pendulum.

The pinion of the centre-wheel (Fig. 5, H) passes through the "lower plate," and besides carrying the minute-hand, with which it revolves once in an hour, carries also a steel pinion, drilled through its axis, and fitted almost tight on to the projecting pivot, which is turned somewhat large for strength. This gears into a wheel which runs on a steel pin screwed into the lower or dial side of the "lower plate," which wheel itself has a pinion turning a wheel running on the hollow pinion.

This wheel is made to travel at $\frac{1}{12}$ of the speed of the centre-wheel pinion, and carries the hour-hand.

In this manner the hour-hand and minute-hand revolve from the same centre, and in the same direction. The wheel H is called the "hour-wheel;" the pinion C, upon which the minute-hand is fixed, is called the "cannon-pinion," being drilled through as a cannon. The object of its not being fitted perfectly tight upon the centre pinion is that the hands may be set backwards or forwards, which they could not be were the minute-hand (through which motion is communicated to the hour-hand) fixed directly upon the centre pinion.

The wheels are all made of brass, well hammered; the pinions of hardened and tempered steel.

Within certain limits a thick watch is preferable to a thin or flat one, as it allows the wheels to be placed farther from the ends of the arbors, whereby the effect of wear upon the pivots or in the holes does not tell so much upon the pitchings or "depths," seeing that one end of the arbor always bears more strain than the other, except in the case of the barrel, which being in the centre of its arbor, gives equal strain upon each pivot, and seeing that the end which is the soonest worn is that immediately nearest to the depth.

Also, in flat watches, any dust getting into the movement more readily affects its going—in fact, sometimes stops its motion entirely, the wheels passing laterally so close to one another.

It will be useful, in recapitulation of what we have already said, once more to draw attention to the figures which accompany the present paper. Fig. 1 shows the brass drum or barrel of the watch. A is the steel cylinder holding spring, B the fusee, C the centre wheel, D and E the third and fourth wheels. Figs. 2 and 4 exhibit, the former an elevation of the spring cylinder and fusee, and the latter a plan of the same, while Fig. 6 shows how the detent, D, acts on the ratchet. Figs. 3 and 3*a* show the driving-wheel from above and below; while Fig. 5 shows the centre wheel, and explains the method of attaching the minute and hour hands. Fig. 7 is the body as seen from below. From this brief description we trust that the arrangement of the component parts of a watch can now be fully understood even by a non-professional reader.

TECHNICAL DRAWING.—LXXXVI.

DRAWING FOR METAL-PLATE WORKERS.

In order that the student may be able to draw the various forms required in "development"—that is, the covering of surfaces, which forms such an important portion of the trade of the metal-plate worker—it is necessary that he should acquire a sound knowledge of the geometrical methods by which the various figures may be constructed with correctness and accuracy.

In "Practical Geometry applied to Linear Drawing," which will be found in the first volume of The Technical Educator, an important system of lessons is worked out. To these, therefore, the student is referred for all elementary constructions, and the following figures are added as being specially useful in the branch of trade to which the present course is devoted.

The student is, however, urged to remember that he cannot hope to succeed in these and the subsequent figures unless he thoroughly understands the preceding ones. He may perhaps be able just to *copy* the drawings, but this is far from being the object with which he should set out.

The right-thinking student will need no argument to convince him that attempting to follow a special branch of a subject, without having previously mastered the elementary portion, will lead to a false result, and will be so much time wasted.

We would, therefore, impress on all who would benefit by these lessons the absolute necessity of working through the lessons already given under the heads of "Practical Geometry" and "Projection."

The methods of inscribing circles in triangles and squares have been given in the course above referred to, and those constructions are now supplemented by the following figures:—

Fig. 626.—*To inscribe within a given equilateral triangle three equal semicircles, having their diameters adjacent and equal.*

Let A B C be the equilateral triangle.

Bisect the angles of the triangle by lines A *a*, B *b*, and C *c*.

Join *a b*, and on this line describe a semicircle touching the sides of the triangle.

To avoid confusion of lines, this semicircle is omitted in this figure, the point only (*d*) where it would cut *b a* being shown.

Fig. 626.

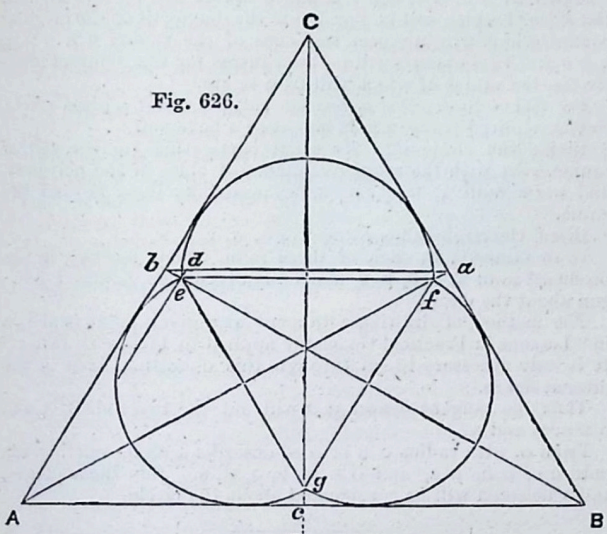


Fig. 628.

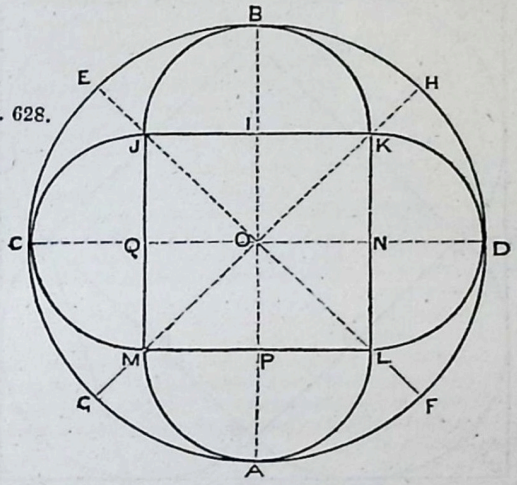


Fig. 629.

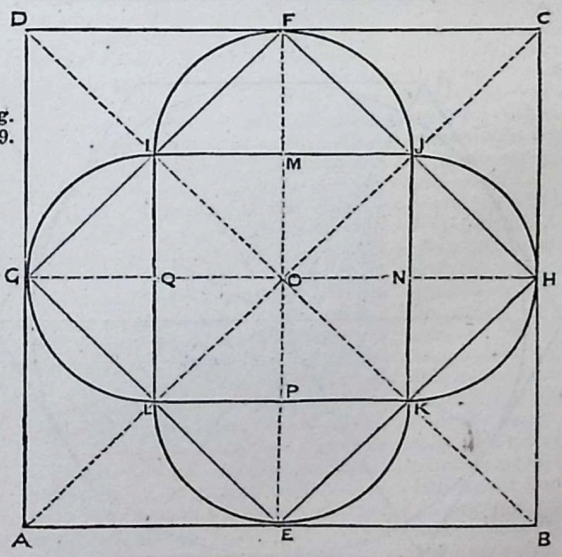
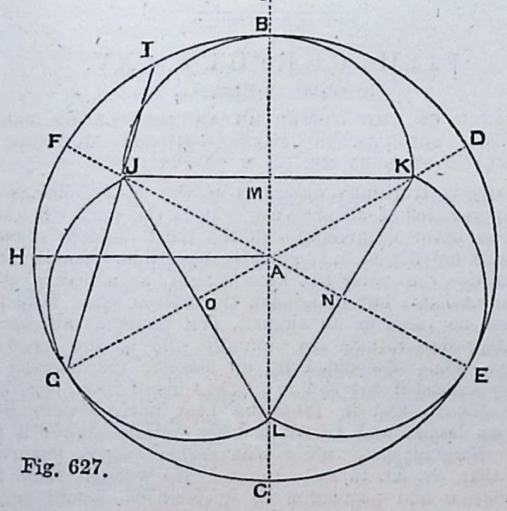


Fig. 627.



From *d* draw a line parallel to C A, cutting *b* B in *e*; from *e* draw a line parallel to *b a*, cutting A *a* in *f*.

Draw *f g* parallel to C A.

Join *g e* by a line parallel to B C.

Then *e f*, *f g*, and *g e* will be the adjacent diameters of three semicircles, the diameters of which are adjacent, and the curves of which will touch the triangle A B C.

Fig. 627.—*To inscribe in a given circle, three equal semicircles having their diameters adjacent.*

Find the centre of the circle, A.

Draw the diameter B C, and from B and C set off the radius of the circle, at F, D, and G, E, thus dividing it into six equal parts.

Draw E F and G D.

Draw the radius A H at right angles to B C.

From F set off F I equal to F H, thus trisecting the quadrant H B in F, I.

From I draw a line to G, cutting E F in J.

From A set off A K and A L equal to A J.

Join J K, K L, and L J, which will give the adjacent diameters of the three required semicircles, the centres of which will be at M, N, O.

Fig. 628.—*To inscribe four equal semicircles, having their diameters adjacent, in a circle.*

Draw two diameters at right angles to each other, A B and C D, intersecting in O.

Bisect the quadrants in E, G, F, H.

Bisect O B in I.

Draw a line through I parallel to C D, cutting E F and G H in J and K.

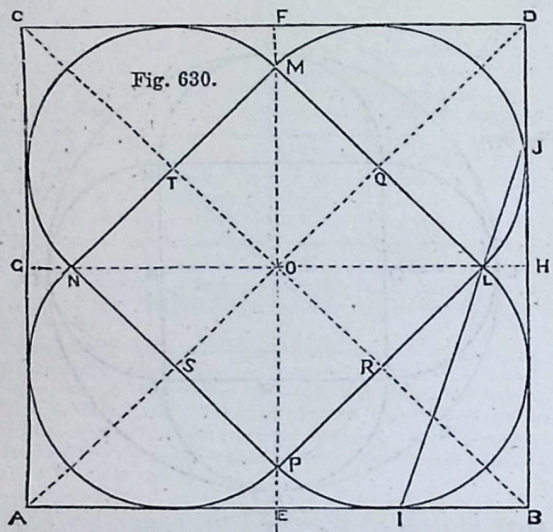


Fig. 630.

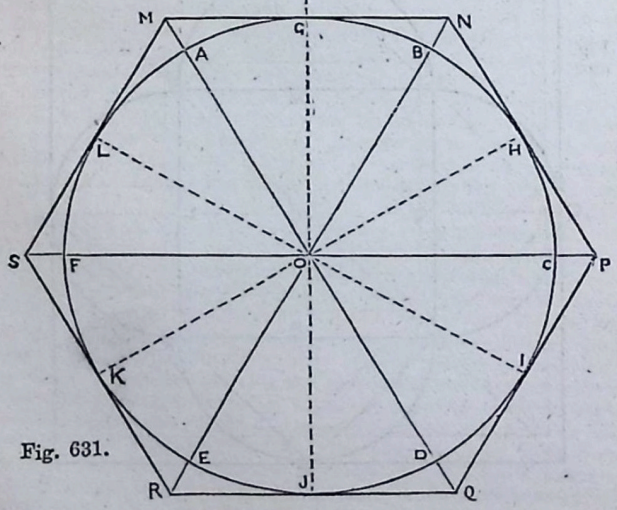


Fig. 631.

Draw K L and J M parallel to A B, and join M L. Then the sides of the square J K L M will be the adjacent diameters of the required semicircles of which I, N, P, Q will be the centres, and I B the radius.

Fig. 629.—*Within a given square to inscribe four equal semicircles, each touching one side of the square and having their diameters adjacent.*

Let A B C D be the given square. Draw the diagonals A C and B D, intersecting in O.

Through O draw E F parallel to B C, and G H parallel to A B, thus dividing A B C D into four smaller squares, each having one diagonal.

Draw the second diagonal in each of these smaller squares, cutting A O, B O, C O, and D O, in L, K, J I respectively.

Draw I J, J K, K L, and L I, thus constructing the square, the sides of which will be the four adjacent diameters of the semicircles, which may then be drawn from M, N, P, Q, with radius M F.

Fig. 630.—*Within a given square to inscribe four equal semicircles, each touching* TWO *sides of the square, and having their diameters adjacent.*

Let A B D C be the given square. Draw the diagonals A D and B C, intersecting in O.

Through O draw E F and G H parallel to A C and A B.

Bisect E B in I, and D H in J.

Draw I J, cutting G H in L.

From O, set off on the diagonals, O M, O N, and O P, equal to O L.

Join L M, M N, N P, and P L, and a square will be constructed, the sides of which will be parallel to the diagonals of the original square, which will intersect the sides of the square L M N P in Q R S T. These points will be the centres for the required semicircles, the radius of which will be Q L, etc.

Fig. 631.—*To describe a regular polygon about a given circle.*

The required polygon is in this case a hexagon.

Divide the circle into six equal parts (this number will, of course, vary with the required number of sides of the polygon), and draw radii A, B, C, D, E, F, producing them beyond the circle.

Bisect the angles thus formed in G, H, I, J, K, L.

Draw tangents to each of these radii, which, meeting in the produced radii A, B, C, D, E, and F, will form the required polygon about the circle.

The method of drawing a tangent at a given point is shown in "Lessons in Practical Geometry applied to Linear Drawing." It is only necessary to go through this operation once in the present figure.

Thus the tangent drawn at G will cut the two radii O A and O B in M and N.

From O, with radius O M or O N, describe a circle cutting the radii O C, O D, O E, and O F in P, Q, R, S. Join these points, and a hexagon will be constructed about the circle.

FISH CULTURE.—XV.

By Greville Fennell.

IMPORTANCE OF THE OYSTER AS AN ARTICLE OF FOOD—MUSSEL CULTURE IN FRANCE—MUSSEL CULTURE IN ENGLAND—THE NACRE.

The oyster is truthfully described as the most delicious and highly appreciated of all shell-fish. It is the most wholesome of all food, never disagreeing with the most delicate stomach. It is highly nutritious, and eminently digestible. Having these good qualities, the oyster has been sought, as a luxury, by all European nations; but in London the artisan class have long recognised its value as an aliment, and immense numbers of the coarser descriptions are annually sold in the streets of this city. Thus consumed by all classes, the demand has gradually exceeded the supply; prices have risen, beds have been exhausted, and in 1865 the best natives were £6 a bushel, wholesale, and 1s. 6d. a dozen retail—almost a prohibitive rising market. Since that period oysters have been no less than 2s. 6d. to 3s. a dozen. No wonder, then, that the formation and protection of oyster-beds should become a subject of grave importance. Mr. Francis Francis informed us in 1865 that "in England, in certain favoured localities, as the eastern coast, companies have had the cultivation of oysters in hand, and are making very handsome revenues from supplying the markets; but they are few, compared with the wide fields which are open to such cultivation. In Ireland the attention of many gentlemen has been particularly turned to this product; and during the year 1860 seventeen gentlemen had obtained licences for the planting of artificial oyster-beds on various parts of the coast. A suitable locality having been chosen and obtained, the cost of planting and preserving an oyster-bed is small, when contrasted with the enormous profits reaped from it, and the subject is well worth the more general attention of proprietors by estuaries, locks, and such localities as are favourable for the planting of oyster-beds. The French are largely engaged in ostreoculture."

This admitted, we will cull a few remarks from the report

on the oyster and mussel fisheries of France, made to the Board of Trade by Mr. H. Cholmondeley Pennell, inspector of oyster fisheries in 1868, and other works and documents which will place our readers in possession of the mode pursued on the Continent in various parts for the cultivation of oysters, etc.

Mr. J. F. Campbell, in his "Life in Normandy," speaks of "oysters in June," and adds, "You always see oysters every market day throughout the year, and I eat them as others do, and find them very good. I suspect that those which are now sold are what are cast up by the tide. The women call them *gite de marée* (oysters of the tide). These may be fish that do not breed, and therefore remain good when others are out of season, for the fishermen do not dredge for them during the summer months; yet the markets are always well supplied with those which the girls collect at low tide on the sands, and, as I have already said, I have always found them very eatable."

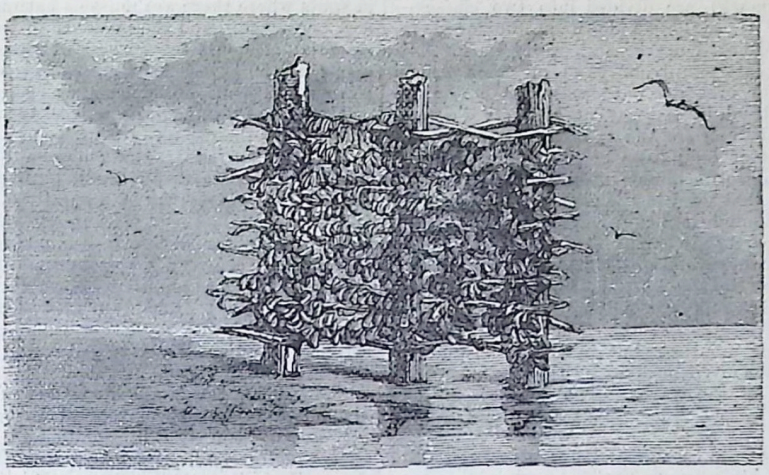


Fig. 33.—MUSSELS FATTENING ON POSTS INTERLACED WITH BOUGHS.

Mussels and Oysters.—It is but twelve years ago that Mr. Cornwall Simeon, in his "Stray Notes on Fishing and Natural History," wrote, "The way in which some of the sea-lochs on the west coast of Scotland teem with animal life is truly marvellous. The shores are in many places literally covered with shell-fish, which are exposed at low water, while the lochs seem to abound with fish almost to an equal extent. The shell-fish mostly consist of oysters, mussels, cockles, and winkles; and when I say that the shores are in parts covered with them, I am not in the least exaggerating the actual fact. I well remember, when I first made acquaintance with that part of the country, my surprise at being shown, in Loch Crenan, a dark-blue bank forming at low water a peninsula perhaps a hundred yards long by some fifty wide; and being told that the colour of this proceeded from mussels, I half thought my informant was joking; but on landing found that he was not only in earnest, but perfectly correct, the whole of it being one mass of mussels (mostly small), lying edgeways, and so densely packed that it would have been apparently a matter of difficulty to insert a pin's point between any two of them. It seemed difficult to comprehend how, under the circumstances, they could manage to open their shells sufficiently for the necessary functions of life. Oysters, too, were numerous; but in consequence of the increased demand for them, they are more sought after than they used to be, and it would not be perhaps now quite so easy to gather a sackfull as it was a few years ago. Vessels also come round occasionally for winkles, and take away cargoes of them to Glasgow; but there are apparently enough to stand such inroads for many a long year to come. On the mussels it would seem that nothing could make the least impression, so vast are the numbers." So much for mussels in Scottish lochs!

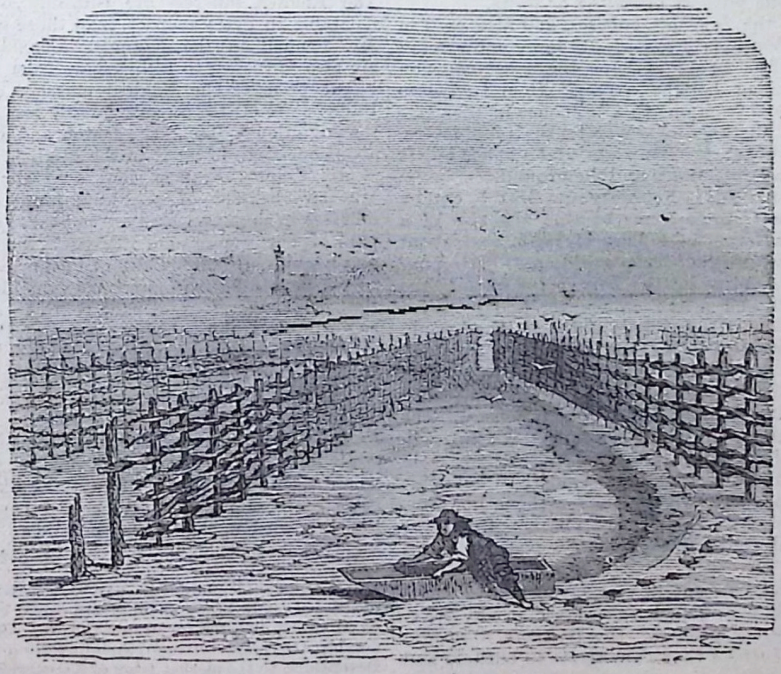


Fig. 32.—THE PIROGUE IN USE AT AIGUILLON.

The simple story of the translation of the vast sloughs at Aiguillon into fertile fields of industry, is that an Irish vessel, having been wrecked in the bay, in the year 1235, only one out of all the crew, named Walton, was saved; and he became the founder of the *bouchot* system of mussel cultivation. He at once set about a means of earning his own food, so that he might not be a burden upon the poor fishermen who had rescued him, and who were themselves, at the time, well nigh destitute of every comfort of life. All around him, however, was one vast expanse of liquid mud, and what could any man do on such a barren field? Walton speedily solved the problem. He first of all invented a craft for travelling upon the mud-bed, for walking was an impossibility, as at every step he sank up to his knees in the miry clay. This boat is called a *pirogue* by the boucheliers, and is still in use, by means of which each man, kneeling in his little wooden vessel with one leg—the other being encased in a great boot is fixed deep in the mud—a lift of the little canoe forward with both hands, and a simultaneous shove with the mud-engulfed leg, and lo! a progress of many inches is achieved (Fig. 32). Thus able to get about, Walton plunged a few stakes into the mud, and to these fastened a kind of purse-net to catch some of the vast numbers of birds which assembled there, to satisfy his appetite. It was out of that little example of a destitute sailor's ingenuity that the present industry of Aiguillon was developed, for it was not long before Walton perceived that the strong posts to which he had affixed his net were covered over with the spawn of the edible mussel. These he found grew very rapidly, and when mature, had a much finer flavour than the mud-grown bivalves from whence the spawn had floated. He therefore went on multiplying the stakes, till there was no end to the produce; so that in time this accidental discovery became a rich inheritance to the humane fisher-folks of the district.

Mussel culture is carried to great perfection at Aiguillon, at the port of Esnandes, and Chatellaillon, in France. Aiguillon

is a small bay, about five miles north-west of La Rochelle, the soil of which is mud of great depth and tenacity. The river Sèvre-Niortaise, and two other smaller streams, debouch in the bay. These furnish a great supply of fresh water, highly favourable for mussel cultivation.

The *bouchots* (fishing-hurdles of the mussel-farms, which extend from the lowest mark of spring-tides to within a short distance of high water-mark) are divided into two classes—viz., *bouchots battises*, or those lowest down on the foreshore, and *bouchots d'amont*, situated nearer high water-mark. The former class, which consist simply of rows of posts driven into the mud, are used for breeding purposes—that is, for the young mussel spat to attach itself to. The *bouchots d'amont*, on the contrary, are used solely for the purpose of growing and fattening. They consist of long lines of posts (Fig. 33), like those we have already described, but interlaced with boughs (*clayonnage*), resembling that used in the construction of sheep-hurdles, but coarser, and much less closely woven, perhaps from two to four inches apart. In this *clayonnage* the young mussels are placed, and are secured in the first instance by being rolled up in lumps about the size of a half-quartern loaf, and roughly enveloped in pieces of old netting, which are then thrust in between the interstices of the *clayonnage*. The net becomes rotten in a few months; but in the meantime the mussels have firmly attached themselves by their byssus, so as to withstand the action of the waves. The *bouchots battises* are entirely uncovered by the tides about ten days out of fifteen.

Formerly the *bouchots* were constructed in the form of a V, with the apex pointing seaward; but it was found that in this form they accumulated mud to an inconvenient extent; and recently a great improvement has been introduced by M. Bellenfant, who substituted for the V-shaped *bouchots* long parallel rows of posts, from twenty-five to fifty yards apart, all pointing directly seaward, so that the tide makes a clean sweep of the mud as it advances or recedes. The V-shaped *bouchots* also formerly answered the purpose of *écluses* or weirs.

The posts composing the *bouchots battises*, and also used in the construction of the *bouchots d'amont*, are large and strong, a diameter of half a foot being perhaps the most common thickness. The interlacing boughs average from twelve to eighteen feet in length, and from one to two inches in diameter at the thickest end. A distance of seven-tenths of a mètre, or about 2 feet 3 inches, separates the posts, and a space is left between the bottom of the *clayonnage* and the ground.

The spatting time for mussels is February and March, and by the end of May the young mussel has become the size of a lentil. In July it is as large as a harvest bean, and about this time it is transplanted to the *bouchots d'amont*. After remaining ten or twelve months in the *bouchots d'amont*, the mussel is about an inch and a half in length, and is fit for market. If left longer on the *bouchots d'amont*, they would doubtless increase somewhat in bulk; but at the age at which they are now sold they are smaller than the mussels usually found on the coasts of the British Islands. In the markets of Paris a much larger mussel finds favour, and some of the mussels from the Mediterranean, which are fully three inches in length, command the highest prices. The mussels are sold almost entirely for consumption, and are considered wholesome all through the year; the best two months for them, however, being August and September. The price of a basket of mussels, called a *mannequin*, and containing about 96 pounds, varies from 6s. 8d. to 8s. 4d.

It is a curious fact that, except in very favourable seasons, the young mussels hardly ever attach themselves, in any quantities, to the *clayonnage*, or posts of the *bouchots d'amont*; whilst on the *bouchots battises* they congregate in clusters and layers, one over another, presenting the appearance of swarms of bees. The layers are easily detached by the hand, peeling off with almost the ease and regularity of a roll of cotton-wool, and under one layer may be constantly found a second.

During the winter months the collecting-posts of the *bouchots battises* are all carefully cleaned of the mud, weeds, etc., which they have accumulated, so as to be ready for the next year's spat.

In the bay of Chatellaillon, eight miles from Rochelle, and five from the mouth of the Charente, a large and thriving mussel fishery is also established, the method, soil, and cultivation pursued being in all respects precisely similar to those of Aiguillon.

The value of the produce from the mussel-farms in the quarter of Rochelle was, for the three years 1865, 1866, and 1867, £87,680. All these mussel fisheries—say about 1,400—are believed to be stocked entirely by the natural spat from the coast; and it is not considered possible to form artificial beds, except in spots where there are mussels naturally.

A muddy soil, and the presence of fresh water, are considered essential elements for successful mussel culture. This is the result of the experience both at Aiguillon and other places in France where the experiment has been tried.

The cost of working the mussel farms is estimated at about one-third of the receipts (*vide* Report to Board of Trade, 1868).

Mr. Pennell says, "The mussel-culture of France has now been for many years an established success, and to the pisciculturist is well worthy of admiration." At the same time, he adds, "I fear, however, that at any rate, so far as the coasts of Great Britain are concerned, it is not equally adapted for imitation. There are very few spots round these shores on which the Board of Trade, as guardians of public rights of navigation and anchorage, would probably permit of the construction of such *chevaux de frise* as those, for example, at Aiguillon, or of the artificial creation of submerged rocks, like the stone *écluses* of the Île de Ré.*

"Moreover, the English method of mussel-culture is both simpler and less expensive, and the mussels usually supplied for consumption at Billingsgate and other large markets are cheaper, larger, and better fattened. Billingsgate, for example, draws its principal supplies of English mussels from Essex. These are purchased from Southend, Leigh, South Lynn, the coast of Devon, etc., and are simply laid down on the mud of the foreshore for seven or eight months, usually from January or February to August, when they are fit for market. During May, June, and July mussels are considered unmarketable in England, not having recovered from the effects of spawning. The English mussels are certainly better fished, and more palatable in every respect than those which were examined by Mr. Pennell on the *bouchots*. Considerable mussel supplies are also furnished to Billingsgate from Holland and Belgium.

The price of the English mussels, at the present time, at Billingsgate (1872) is considerably less than half the price of the Aiguillon mussels, the Dutch and Belgian mussels varying about one-sixth lower than the English.

Mr. Francis Francis, in his "Fish Culture," says, "There are few shell-fish of any kind found upon our coasts, from lobsters to limpets, which are not more or less valuable to some part of our population. Mussels, cockles, shrimps, whelks, and winkles, are all articles of food or commerce, many forming indispensable baits in our more valuable fisheries. Due attention should therefore be paid to their cultivation and supply, as, owing to reckless fishing, some of them have been seriously diminished. A slight notion of their actual value can be formed from the fact that the supply of whelks alone, obtained off the Herne Bay flats (now handed over to a private company), and sold either to the North Sea cod-fishers, or the London market for food, realised something like £15,000 to £20,000 a year, while in many places the sums realised from the sale of mussels would seem incredible. Of anything like the cultivation of lobsters, crabs, and such members of the crustacea, we have so little knowledge, that it may be said to be still an occult or unknown science, though there cannot be a doubt but that artificial

* It is possible, however—nay more, extremely probable—that the mouths of many of our tidal rivers would be found on examination to be admirably adapted for oyster-culture. Some of these estuaries, and notably the large estuary extending from the port of Salcombe, in Devonshire, to the market town of Kingsbridge, about six or seven miles in length, and about the same in width in many parts, seem to be admirably adapted for oyster-culture, and no impediment would be offered to navigation, as the coasting vessels which go up to Kingsbridge are obliged to keep to certain channels between the mud-banks that are visible in all directions at low water. On the Saltstone, a large and broad platform of rock in the lower part of the estuary, might be made excellent collectors for breeding purposes, while oysters might be fattened to perfection on the mud-banks which stretch up to the foreshores. The expense of gathering the oysters would be comparatively small, as it would be done by rakes. The estuary of the Dart, between Dartmouth and Totness, and other similar estuaries, would afford equal facilities for oyster-culture.

means of rearing and feeding them might be easily employed with success. To my knowledge, it has never even been tried. I know but of one small pool, near Titchfield, at the mouth of Southampton Water, where lobsters are placed; and this is a mere stew, in which they are kept for a few days until required. There are, however, numberless places where fortunes could be realised, and vast stores of food provided for the people. In France the practice is followed out to some extent; and at Concarneau, on the coast of Brittany, there are a series of ponds or *viviers* hollowed out of the rock, in which large quantities of crawfish and other fish are raised and nursed for the markets. Such ponds abound around our own coasts, and there is scarcely a harbour or a river's mouth where something of the kind might not, with the utmost ease, be carried out."

At low water, at Boulogne, there were such quantities of mussels near the town, that a cart-load might have been gathered there, and then they would not have been missed.

Oppian speaks of the nacre. This shell-fish is a species of mussel, and furnishes mother-of-pearl. A little fish, of the crab genus, resides within the shell of the nacre, and the above Greek poet treats the connection as a sort of partnership for obtaining food. These mussels were called by the Greeks *pinnæ*, and the small fish that lived in the same domicile *pinnatores* and *pinnophylax*. The nacre, to prevent itself being driven about by the motion of the sea, spins a quantity of long silken fibres, which it attaches to rocks, or any substance—even the sand. These fish are about a foot long, but have sometimes attained the length of two feet. They were formerly much sought after, in order to obtain the silky fibres, which being spun into threads, were manufactured into a variety of articles of dress. The common mussel sends out a number of filaments, and by the observations of Reaumur those filaments are for the same purpose of fixing itself to some solid substance. On opening mussels, a little bunch of green fibres will be seen; these are the parts produced by the fish, whereby it keeps itself upright; and these fibres, if not extracted before the fish be eaten, are very dangerous to the health, because the other portions of the fish easily digest, leaving a mass of these fibrous substances, which are indigestible, to accumulate together by the motion of the stomach, producing in a strong constitution considerable disturbance, and in a person of very delicate habit of body dangerous and even fatal consequences.

Mussels have from time immemorial been a favourite food; but as at some seasons they are very unwholesome, many cases of serious illness, and even of death, have occurred from eating them. "The faculty," Mr. Gwyn Jeffreys observes, "seem to be completely at fault as to the nature of this poison. By some it is attributed to the mussels living among putrescent matters, as in docks, and near the outlets of public sewers; by others to their feeding on the spawn of star-fish, which are well known to be poisonous; by others to their being too freely eaten, and causing a surfeit; or to a morbid state of the system in the persons eating them; by a few to their imbibing into their tissues a solution of copper; and Delle Chiaji showed that in many instances it was owing to these mollusks being at the time in spawn, and therefore out of season. A strange notion once prevailed that the poor little pea-crab was the author of all the mischief."

It is stated that mussels are used at Bideford to fix, by means of their byssus, the stones of a bridge, which is difficult to keep in repair, owing to the rapidity of the tide. The interstices of the bridge are filled with them, and it is said that only their strong threads support the fabric, and prevent it being carried away.

THE LATHE.—XII.

By Henry Northcott.

OTHER TOOLS AND INSTRUMENTS USED BY THE TURNER.

In addition to the tools for cutting the various materials operated upon, other instruments are necessary for holding the work in position attached to the lathe-spindle whilst being rotated and turned, for measuring the dimensions of the article, gauging the depth and angle of the cut, and for various other purposes.

The instruments for fastening the work to the lathe-spindle are mostly known under the name of "chucks." Several of these have already been shown upon the lathes themselves, and it will be seen they are all screwed upon the nose of the lathe-spindle, which should be screwed with a strong coarse-pitched V-thread, rounded well off at both the top and bottom angles, and case-hardened. If the spindle-nose is made too small, it is very apt either to be wrenched off altogether or twisted out of truth by any sudden and exceptional strain; and if it is made too large in diameter, the bosses of the chucks become heavy and clumsy. If the screw-thread upon the spindle be too fine, a very little wear makes a bad fit; and also after using a chuck to carry work from which a heavy cut has to be taken, the chuck is found screwed up so tight against the collar of the lathe-spindle, that some extraordinary means have to be taken to remove it.

In Figs. 7 and 8 (Vol. II., pp. 406, 407) a chuck or driving-plate is shown on the lathe-spindle. This is chiefly used for turning metals, and a piece is shown in place between the centres. At Fig. 11 (Vol. III., page 92) also there are several chucks shown ranged upon the lathe-bed; that one at the extreme right is the face-chuck or face-plate. Fig. 82 is a very useful instrument for driving pieces of wood of small diameter, that can be supported at the other end by the steel centre-point. The shank is made to fit into the hole in the lathe-spindle where the steel centre-point is also fitted. Sometimes this hole is furnished with a screw-thread, and sometimes it is a smooth tapering hole, so the shank of the driving instrument must be made to suit. The central pin of the driver (Fig. 82) should be turned up whilst the driver is in its usual place, as its function is to ensure the centrality of the turned work, although the article may be removed occasionally from its position between the lathe-centres. The two projecting edges of the driver are forced into the wood to be turned, and the deeper they are embedded the heavier is the cut they will stand without slipping round or shearing the wood.

Fig. 83 is a carrier or driver. Its use and position are clearly shown at Figs. 6 (Vol. II., p. 405), 7, 11, etc. The pin at the side of Fig. 84 is for tightening up and slacking back the nipping-screw of the carrier. The driver is chiefly used for metals.

Fig. 84 is a very useful instrument called the "scroll chuck." It is chiefly used for holding round flat pieces of iron or hard woods, which do not require the further support of a centre-point at the right hand. The three jaws may be simultaneously moved either towards or from the centre of the chuck, by means of a spiral or scroll-plate in the body of the instrument, which gears with a kind of spiral rack cut upon the back of the jaws. The body of the chuck is usually made of cast iron, and the jaws of wrought iron case-hardened. The jaws are actuated by means of a box wrench or key, which is inserted in the small recess at the side of the flange. The chief advantage of this chuck is that articles are chucked or fixed concentric at once, without needing any skill on the part of the user, or adjustment of the chuck. They are made in sizes from three inches diameter of flange to about nine inches, but the larger sizes are very heavy instruments. The chuck will receive an article between its jaws of about the same diameter as its flange, but of course a ring of much larger diameter than this can be chucked upon the outside of the jaws.

Fig. 85 shows another variety of the self-centering chuck, designed for holding rod-iron and larger wire whilst it is being turned into screws or other forms. It is also used for holding spiral drills, one of which is shown fastened between the jaws. The key at the side is inserted into the cavity on the edge of the chuck, and twisted round to open or close the jaws.

Fig. 86 is also a self-centering chuck. It is used chiefly for holding small drills as shown. These drills are very efficient instruments, and have come into extensive use in almost every workshop. They will drill through either metals or hard woods; they clear their own holes of shavings, and with fair usage they retain their shape and size until worn out, which is not the case with the ordinary drills. Fig. 87 shows the spiral drill with straight shank, and Fig. 88 with a tapering shank, whilst Fig. 89 is a holder or socket for the drills with tapering shanks.

The wrench or spanner at Fig. 90 is used for fastening the headstock or poppet down on the bed, and for many other purposes. The square at Fig. 91 and the bevel (Fig. 92) are used to determine the angle of one turned surface with another, and the square is also required for adjusting the position of work upon the face-plate and for other work. The standard gauges shown at Fig. 93 are instruments turned to special set sizes, and used in reproducing their own exact diameters. They are

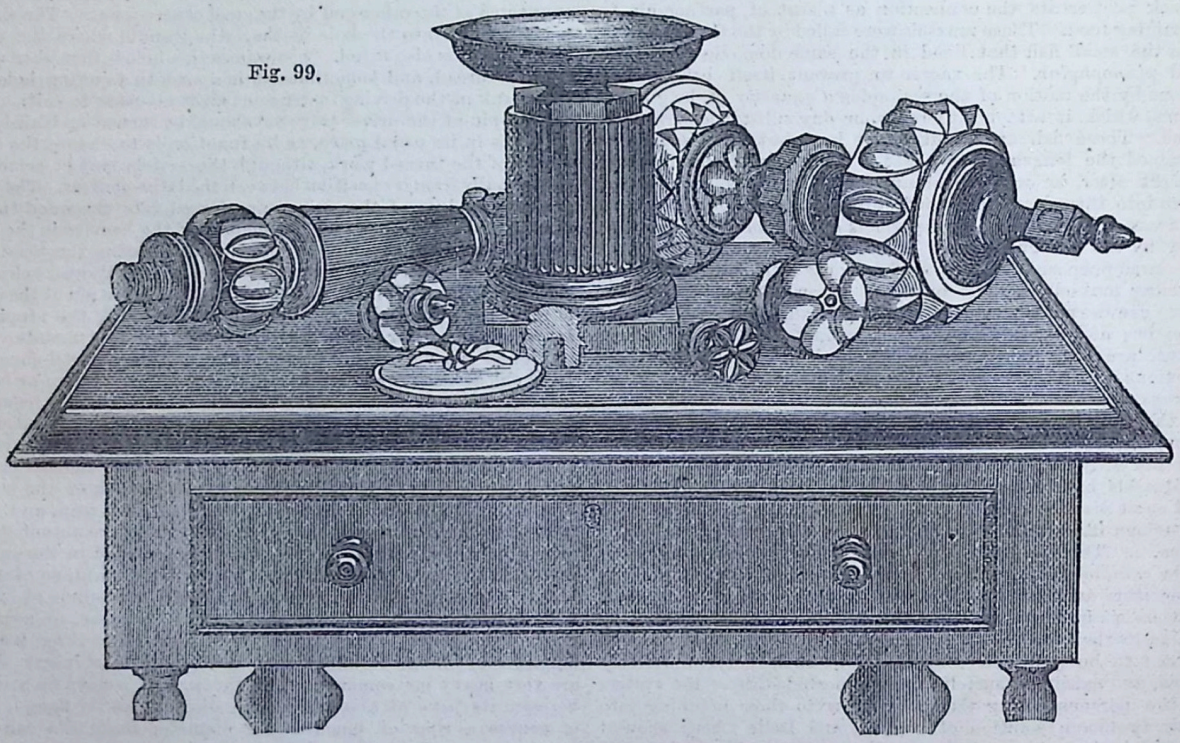
used solely for metal turning. The dividers (Fig. 94) and the compasses (Figs. 95 and 96) are used for finding the centre of the rough materials, for measuring lengths; and the very useful instruments at Figs. 97 and 98 are called "callipers," and are used for measuring the diameters of cylinders and cylindrical holes and other such work.

The articles the hand-turner is called upon to produce are very numerous and various, but amongst them may be mentioned round rulers, tool-handles, cotton-reels, bread-plates, drawer-knobs, egg-cups, chessmen, table-legs, billiard-balls, cubes, pillars, and vases of every shape. Some of these are illustrated in Fig. 99, and although the exact mode of using the tools and executing work can only be learnt by practice, it will be useful to take some of these articles as examples, and explain the various steps a workman would take in producing them.

In turning, say, an ordinary cylindrical ruler, the first thing is to choose the wood. These instruments are generally made of some moderately hard wood, such as mahogany, rosewood, lignum vitæ, or ebony. Most of these woods can be turned with either class of tools, excepting when they are very old and indurated, or of unusually hard quality. The piece of rough wood chosen, if tolerably straight, need be very little larger in diameter than the ruler is to be when finished. It should be cut off rather longer than the complete ruler—say half an inch longer. The projecting corners should be chopped off, and the piece rounded off somewhat if it has been cut from the plank, but if it is a round branch of wood very little need be done to it to prepare it for turning. Loose the tool-rest and the right-hand poppet, and draw the latter along the lathe-bed into such a position that the piece of wood will go conveniently between the lathe-centres. Fix it in this position by tightening up the nut of the headstock. Screw out the cylinder carrying the right-hand centre-point, by turning round the hand-wheel at the right, but only put sufficient pressure upon the screw to hold the wood lightly between the centre and the centre-point of the driver. Apply the flat of the hand lightly to the wood, and draw the hand across the wood so as to move it round. If the wood runs very much *out of truth*, or out of centre, take hold of one end of it, and, keeping it pressed against one centre, slightly remove the other by unscrewing the forcing-screw of the headstock, and then replace the centre against the end of the wood, but in a position rather nearer the side of the wood which appears furthest from the centre. If necessary serve the other end the same. Rotate the wood again a few times, and if it be still out of truth remove the centre-points into fresh positions, and continue doing this until the piece of wood is fairly hung between the two centre-points. When the proper centres have been found in this or other convenient manner, the forcing-screw can be screwed up until the centre-points and the horns of the driver are pressed into the wood deep enough to drive it and support it whilst being turned.

Then adjust the position and height of the tool-rest, bringing the edge of the rest as near the work as it can go without coming in contact with the edges of the wood. It is always advisable to pull round the lathe-spindle once or twice by hand before fastening the tool-rest down, so as to make quite sure that no projecting part of the wood does come against the rest. Fasten down the tool-rest upon the lathe-bed, put a drop of oil about the right-hand centre-point where the wood runs upon it, place the gut on the proper pair of grooves for giving the required speed to the wood as already explained, and set the lathe in motion.

Fig. 99.



The roughing-down tools are then to be applied to the rotating surface of the work, and the whole length of the wood *trued* or *roughed up*. Set the callipers to the size the finished ruler is to be, and with the finishing tools remove the rough lines left by the other tools, and carefully take off sufficient material—and only sufficient—to enable the callipers to go easily astride the ruler in every place. As before observed, nearly the whole of the material should be removed with the roughing tools, and only enough left to allow of rough lines being obliterated by the sharp finishing tools. In turning a long cylinder, whether in wood or iron, it is generally a good plan to turn down a series of bands all along the work to the required size, as these bands then guide the turner in turning the remainder of the cylinder. The surface of a ruler has, of course, to be very smooth and straight. The edge of a square or of a thin blade of steel made straight for the purpose, and called a "straight-edge," is occasionally placed along the upper part of the cylinder, so that by looking between the two edges in contact the turner may judge of the parallelism of his work. When the ruler is nicely turned upon its face, its ends are rounded off with the suitable side-tools, and the whole may be rubbed over with a

piece of old glass-cloth, or a handful of the fine shavings that have been turned off. Either may be moistened with a few drops of oil, and held against the wood whilst it is running. This brightens the surface and brings up its grain.

In turning up a surface—say a bread-platter—the wood is cut from a plank, and if the wood is valuable it is cut round at once with a sweep-cutting saw; but if cut out square, and the wood is not very valuable, the corners must nevertheless be cut off, and the wood rounded as much as possible before it goes to the lathe. This is advisable because, whereas such corners can very easily be rounded off with a small saw, they are rather awkward to deal with when running round in the lathe. They are apt to knock an inexpert workman's tools out of his hands, to break the screw or other chuck to which the wood is fastened, to cause the wood to split, and also to absorb a good deal of power, as the turner soon finds out if the work be attempted on a foot-lathe. When the flat piece of wood is prepared, it is fastened to the lathe-spindle by means of a suitable chuck or face-plate, and is turned up roughly as in the last example. The right-hand poppet is not required for this kind of work, and it should be pushed back out of the way; and as the speed for this work or the edges of it will be comparatively low, the gut-band should be shifted into the largest of the lathe-spindle pulleys. The best plan, generally, is to turn one surface smooth and to the proper shape, complete, and then to turn it over and chuck it upon the finished side, taking care that the work beds fairly against the surface of the chuck, so that the one part may be true with the other. For flat articles which do not admit of having holes made in them, the usual mode of chucking is by means of a composition called Turner's Cement. Any flat chuck of suitable diameter is warmed, and a piece of cement rubbed over its face, and the article to be chucked is pressed well down upon the cement. When the chuck cools the wood is firmly cemented to it, and with care a fair-sized cut may be removed without detaching the work from its chuck. After the article is finished, it is removed by a slight tap with a hammer. In using the cement it is always advisable to have a fairly true surface to come against the chuck; and it is sometimes necessary to plane up the rough wood, in order to obtain one. But, as a rule, a little time spent in preparing work for chucking saves a good deal of time and trouble when turning it. It must always be borne in mind that the thinner the coating of cement between the chuck and the article, the less is the likelihood of the finished work being out of truth, as it is difficult to ensure a perfectly even coating of the cement upon the entire surface of the chuck. And it is a mistake to imagine that the holding power of the cement is increased by its being laid on thickly.

To turn a perfect cube in the lathe would appear at first sight an impossibility; but in reality this is a most simple form to produce—much more so than the sphere. The cube is a six-sided solid, and all its sides are plane surfaces. We already know that it is as easy to turn a plane surface in the lathe as to turn a cylinder, and to produce a cube it is only necessary to turn six plane surfaces in certain positions, the one with the other. The turner would proceed as follows:—He would first take a piece of wood sufficiently large to enable him to turn a cylinder out of it, with a diameter equal to the diagonal of the square side of the cube. And this also he would do, cutting the cylinder off to a length equal to the side of the square. This would then show a short cylinder with two flat ends, or a thick flat disc, and this disc would be placed in a chuck in a position at right angles to the position in which it was turned; that is to say, the axis of the cylinder is placed parallel to the surface of the chuck; and the lathe being set in motion, a third surface is turned upon the article, which is then removed from the chuck, and replaced with this third flat surface bearing against the surface of the chuck. In this

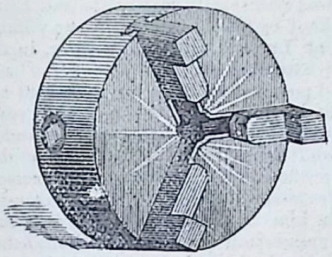


Fig. 84.—SCROLL CHUCK.

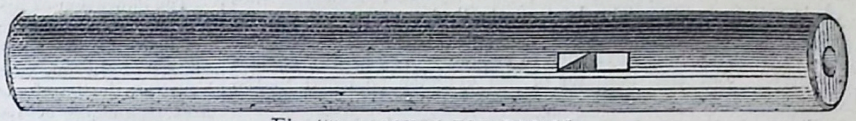


Fig. 89.—SOCKET FOR DRILLS.

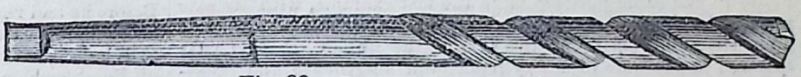


Fig. 88.—TAPER-SHANK DRILL.

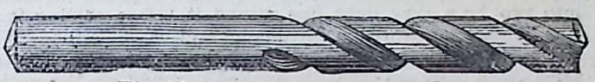


Fig. 87.—STRAIGHT-SHANK DRILL.

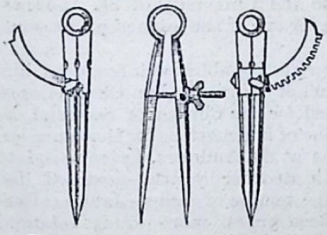


Fig. 96. Fig. 94. Fig. 95.

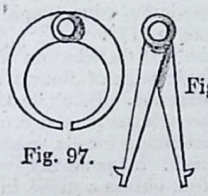


Fig. 97. Fig. 98.

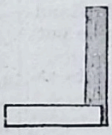


Fig. 91.

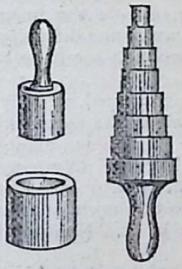


Fig. 93.—STANDARD GAUGES.

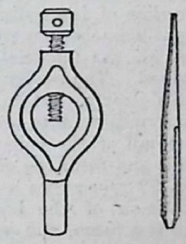


Fig. 83.—LATHE CARRIER.

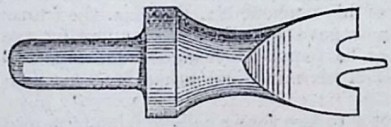


Fig. 82.

Fig. 92.

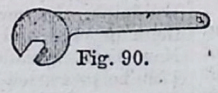


Fig. 90.

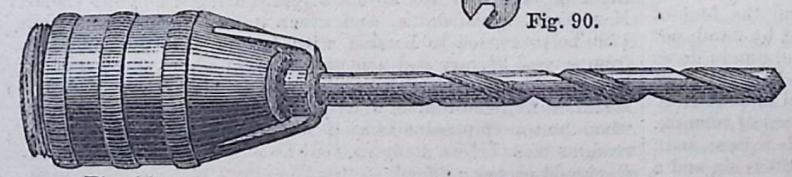


Fig. 86.—UNIVERSAL CHUCK, WITH A STRAIGHT-SHANK DRILL.

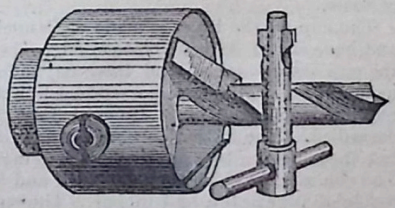


Fig. 85.—SELF-CENTERING CHUCK.

position a fourth flat surface can be turned upon the article, and if the settings have been carefully made, these two last surfaces revolve at right angles to the two forming the ends of the cylinder. Two further similar settings of the work in the chuck will enable two other surfaces to be turned, and these will complete the cube.

There is no difficulty in producing a solid of any other number of sides. The production of the cube is more of a puzzle than a difficulty, because knowing the mode of its production removes the difficulty. To produce a perfect sphere, however, requires somewhat more address and skill on the part of the workman. Turners who are in the habit of producing billiard-balls and other spheres in large numbers become wonderfully quick and exact; but the beginner may generally expect a slight trial of his patience, and the exhibition of a good many balls anything but perfect spheres, before he succeeds satisfactorily. The best method of turning spheres by hand is as follows:—Take a piece of wood of the required size, and turn out a short cylinder in the same way as in the last example. Let the diameter of the cylinder be equal to the diameter of the required sphere, and let the length of the cylinder be the same as its diameter. Chuck this short cylinder in the same position as in the last example, with its axis parallel to the surface of the chuck, taking care to so adjust it upon the chuck as to let the axis of the lathe's rotation pass through the middle of the cylinder both lengthwise and crosswise. It is always a good plan to divide the cylinder accurately into two by a very light line around it before cutting it off. The lightest touch with a sharp point will be sufficient. When the work is properly chucked the lathe is set in motion, and some sharp tools are carefully applied to round off the projecting parts and produce one half the sphere. In doing this, as the outline of the cylinder will in rotating describe a sphere, this outline acts as a very efficient guide, and the workman removes all the material lying outside the imaginary sphere so described. The reader may have some difficulty in understanding this clearly, but he will probably see it better when he puts the instructions into practice.

One half of the sphere being formed, it only remains to reverse it and form the other half in the same way.

Fig. 99 represents a group of articles exhibited at a recent competition of the London Turners' Company. The central object is a tazza, and was exhibited by Mr. Edwin Baker, who also turned the two small objects shown in front of the tazza, and the small articles shown in it. None of these, however, were exhibited.

The other objects were all exhibited by Mr. Battersbie, and are all turned in a very plain foot-lathe, and with the plainest of tools.

The cup of the tazza is made of Cannel coal, and the column and base are of African blackwood. The edge and the foot of the cup are octagonal, and these flat sides are cut by hand, not in the lathe. They can be produced in the lathe, but to do so requires apparatus of a different kind to what has yet been described. The flutings are also made with special instruments, but these belong to a more advanced stage of the art of turning. The column has thirty-two flutings, and its base is square, with a side of four and a half inches. The entire height is six and a half inches. Cannel coal, of which the cup is formed, is a very dirty material to work. It is brittle, and comes away in small dust and chips, but receives a very fine polish when properly turned. The tools necessary for this material are ground with an obtuse cutting angle, much the same as for hard-wood turning. African blackwood is a very fine wood. It turns well, and receives a first-rate polish.

The two objects in front are profile heads. The wood is turned into such a shape that its section shows a man's head. The one with the nose is, of course, the Duke of Wellington. The other is meant for Mr. John Bright. A similar system of profile turning is used to produce the toy animals in Noah's-arks. They are first turned in rings to a certain section, then cut into slices, and carved into shape. The other articles are made of mahogany, boxwood, and black ebony. The forms are produced in the usual manner, and the ornamentation is effected by separate chuckings of the work, so as to present it to the tool in various positions, in much the same manner as when producing the cube. But very much larger chucks are necessary for this kind of work than for ordinary turning.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXIX.—SIR JOHN LESLIE, K.H., F.R.S.E.

BY JAMES GRANT.

Sir John Leslie, so distinguished for his discoveries and writings, the inventor of the hygrometer, by which water and mercury may be converted into ice, and the inventor of the differential thermometer, was born at the picturesque little village of Largo, in Fifeshire, on the 16th of April, 1766. He was the son of a poor joiner, named Robert Leslie, and of Anne Carstairs, his wife, a native of Largo. His father came originally from St. Andrews, and though poor his means and humble his occupation, in point of education and attainments he was far above the people of his station.

The education of his son was necessarily scanty at first, being obtained first at the school kept by an old woman in the village, and afterwards at another at Lundin Mill, and thirdly, in the village of Leven, where he attended only six weeks. There, however, the barefooted and poorly-clad little boy obtained the first rudiments of Latin, and while at home received some lessons in mathematics from his elder brother Alexander. Before he had reached his twelfth year he attracted considerable notice by his extraordinary proficiency in geometrical exercises, and he became known to Professor Robison, of the University of Edinburgh, and through him to Professors Playfair and Dugald Stewart, at whose suggestion his parents, though but ill able to afford the expense, inspired by that desire, so honourable in the Scottish poor, to educate and raise their children above themselves, sent him to the University of St. Andrews, with the view of educating him for one of the learned professions. This was in 1779.

At the first distribution of prizes his abilities introduced him to the patronage of Robert Earl of Kinnoul, then Chancellor of the University. Being destined for the Church of Scotland, he went through the regular routine of instructions for that purpose. After attending for six sessions at St. Andrews, he removed to Edinburgh, in company with another youth—destined like himself to obtain a niche in the temple of fame—James (afterwards Sir James) Ivory. Three years' more study followed at the old Academy of James VI., where he obtained an introduction to the celebrated Dr. Adam Smith, who employed him in assisting the studies of his nephew, Mr. Douglas, the future Lord Reston; and he now gave up all idea of adopting the Church as a profession, as he found it altogether incompatible with the strong turn which his mind had taken towards physical studies.

On being appointed tutor to two young college friends, named Randolph, who were natives of Virginia, he accompanied them there in 1788, and was absent a year, during which he visited New York, Philadelphia, and other transatlantic towns. In 1790 he proceeded to London, with letters of recommendation from several literary and scientific men, of whom there were no lack then in the Scottish capital, and among others from Dr. Adam Smith, who told him, at parting, that "if the person to whom he was to present himself was an author, to be sure and read his book before doing so, that he might be able *to speak of it*, should occasion offer."

Young Leslie's first intention was to deliver lectures on natural philosophy; but finding, to use his own words, that "rational lectures would not succeed," he had recourse to his pen as the most ready means of support, and began to contribute articles for *The Monthly Review*. About the same time he was employed by an old fellow-student, Dr. William Thompson, the continuator of Watson's "Reign of Philip III. of Spain," to furnish notes for an annotated edition of the Bible (then publishing in numbers), which he did under the name of Harrison. By Murray, the bookseller, he was next employed to translate Buffon's "Natural History of Birds," published in nine volumes in 1793, and the payment for this, with his prudent habits, laid the foundation of his subsequent independence.

While this work was in progress, he fulfilled an engagement with the Messrs. Wedgwood, of Etruria, in Staffordshire, to superintend their studies. He left them in 1792, and two years later he visited Holland. In 1796 he made the tour of Germany and Switzerland with Mr. Thomas Wedgwood, whose untimely demise he ever mourned as a loss to science and his country.

Previous to 1800 he had invented the differential thermometer, which is described as "one of the most beautiful and delicate instruments that inductive genius ever contrived as a help to experimental research; and the result of his inquiries concerning the nature and laws of heat, in which he was so much aided by this exquisite instrument, was published in 1804." This was his celebrated "Essay on the Nature and Propagation of Heat." Though defective in method, somewhat questionable in theory, and indifferent in style, its striking discoveries and experimental devices more than atoned for all its faults.

On the promotion of Professor Playfair from the chair of Mathematics to that of Natural Philosophy in the University of Edinburgh, Mr. Leslie offered himself as a candidate for the vacant professorship; but his election was vehemently opposed by the moderate party among the city clergy, who were desirous of placing one of their own body, Dr. Thomas MacKnight, in the chair. They grounded their objection to Mr. Leslie upon a note to his Essay on Heat, which referred to Hume's theory of causation; and hence they deemed it of an infidel nature and tendency.

Keen discussions followed in the ecclesiastical courts; but in these Mr. Leslie was stoutly defended by Sir Henry Moncrieff, the case was dismissed by the General Assembly, and in consequence, he entered, without further opposition, on the duties of his chair. Previous to this period, and when not otherwise engaged, he was wont to live with his brothers in his native village of Largo, where originally all the experiments for his "Essay on Heat" were carried on, and where the book itself was written.

Through the assistance of one of his many ingenious contrivances—his hygrometer—he arrived, in 1810, at the discovery of that singularly beautiful process of artificial congelation, which enabled him to convert water and mercury into ice. In the *Scots' Magazine* for that year there is a description of the process, which then greatly excited the attention of the public. A brother professor writes thus:—"We happened to witness the consummation of the discovery—at least the performance of one of the first successful repetitions of the process by which it was effected; and we shall never forget the joy and elation which beamed on the face of the discoverer as, with his characteristic good nature, he patiently explained the steps by which he had been led to it."

In the preceding year he had published his "Elements of Geometry," which immediately took its place as a class-book, and has since gone through several editions. In 1813 appeared his "Account of Experiments and Instruments, depending on the relation of Air to Heat and Moisture;" and in 1817 he printed his "Philosophy of Arithmetic, exhibiting a Progressive View of the Theory and Progress of Calculation." In 1821 his "Geometrical Analysis" appeared, and in the subsequent year his "Elements of Natural Philosophy," for the use of his class. A small octavo, published in 1828, entitled "Rudiments of Geometry," designed for popular use, was his last separate work; but he was author of many excellent articles in the *Edinburgh Review*, then in the zenith of its fame; of three profound treatises in "Nicholson's Philosophical Journal;" a few in the "Transactions" of the Royal Society of Edinburgh; and of several valuable articles in the supplement to the "Encyclopædia Britannica."

In 1819, on the death of Professor John Playfair, whose promotion had formerly made room for him in the chair of Mathematics, he was elevated to the professorship of Natural Philosophy. By this the great powers of his mind had a wider field for display and use than they had possessed for the fourteen preceding years.

Among the preliminary treatises of the seventh edition of the "Encyclopædia Britannica," which began to appear in 1830, he wrote one on "The History of Mathematical and Physical Science during the Eighteenth Century," which attracted great attention from its agreeable and masterly style.

On the recommendation of Henry Lord Brougham, then Chancellor, he was invested with the Knighthood of the Guelphic or Hanoverian Order, at the same time that Herschel, Charles Bell, Ivory, Brewster, South, and Harris Nicolas received a similar mark of distinction; but he was not destined long to enjoy the honour conferred upon him. The income he enjoyed for many years was far above his necessities, and thus, in time, he amassed the sum of £10,000. In his latter days he expended the most of this in the purchase and decoration of a mansion, called "The Coates," near his native village in Fifeshire, where he spent all the time he could spare from his duties at the University. But in the end this proved a fatal acquisition.

In the October of 1832, while superintending some of the improvements at Coates, by incautious expesure, he caught a severe cold. Among the few foibles he possessed was a singular contempt for medicine, and an unwillingness to believe that he would ever be seriously ill. Hence he neglected an ailment that at first was slight, but he was soon seized by a disorder, at that time very prevalent in Scotland—erysipelas in one of his legs. On the 31st of the same month he was rash enough to expose himself again. The fatal malady rapidly advanced, and on the evening of Saturday, the 3rd of November, 1832, he expired, in the sixty-sixth year of his age.

The person of Sir John Leslie, especially in his later years, has been described as being far from gainly. "He was short and corpulent, with a florid face and somewhat unsightly projection of the front teeth, and he tottered considerably in walking. He was, moreover, very slovenly in his mode of dressing—a peculiarity the more curious, as it was accompanied by no inconsiderable share of self-respect, and an anxiety to be thought young and engaging. The mixture of great intellectual powers with the humbler weaknesses of human nature can seldom have been more strikingly exemplified than in his case; though it is evident that, as his weaknesses were very much those to which unmarried men in advanced life are supposed to be peculiarly liable, "that might have been," says Robert Chambers, "obviated in a great measure if he had happened to spend his life in the more fortunate condition of matrimony."

One of his little vanities was to have his hair dyed; but unfortunately the colours often varied or refused to mingle. He was, however, the most placable of human beings, was a kind friend, a tender relation, and good man in all his ways of life. "There is one other matter," says Macvey Napier, "which, in justice to the illustrious dead, we cannot pass over in silence: We mean the permanent service rendered to the class of natural philosophy by the late Sir John Leslie, in the collection of by far the finest and most complete set of apparatus in the kingdom." Among the many monuments erected to eminent men in Scotland there has been none as yet raised to Leslie.

INDIAN RUBBER.—IV.

By George Gladstone, F.C.S.

ELASTIC WEBS—EFFECT OF GREASE—OF SUNLIGHT—TELEGRAPHY — VULCANISATION — ITS IMPORTANCE — HOW PRODUCED.

The threads, the cutting of which was described in the last article, are used in the weaving of webs which shall be elastic in character. The very elasticity of the material, however, rendered it difficult at first to produce an article which should lie flat, because if one thread was stretched more than another in the loom, it would, when taken out, cause the web to contract unevenly.

Prior to the weaving, the threads are stretched to the full, and then rendered inelastic, so that they can be manipulated like any other article. The stretching is accomplished by first heating them in warm water, which increases their elasticity, so that they can be drawn out to seven or eight times their natural length, which is done by the tenter boy or girl through whose finger and thumb each thread is drawn as it is wound upon a reel. In the process of extension a great deal more heat is developed, so much so as to be exceedingly uncomfortable to unpractised hands; the effect upon the Indian rubber appears to be very similar to that upon metals in wire-drawing, as they also become heated and hardened under the operation, and have to be subsequently annealed to regain their tenacity. The threads are left upon the reels, and thoroughly cooled for several days before use, by which time they will have quite lost their elasticity.

The filaments of rubber form the warp of the elastic band, or the foundation of the braid, and are worked up with silk, cotton, or other thread in riband looms or braiding machines. On the fabric being completed, the Indian rubber threads are

again rendered elastic by the application of a moderate heat, say about 150° Fahrenheit. This is usually done by passing a heated iron or roller over the articles, when the fabric contracts, and draws all the threads very closely together. If it is intended to produce a pattern upon the goods, an allowance is made for the amount of subsequent shrinking, so that the design may ultimately appear in its proper proportions; some articles, however, are always slightly stretched when in use, which forms a second element in the calculation when laying out the pattern for such goods.

All kinds of grease exercise a deleterious effect upon caoutchouc, destroying its elasticity, and reducing it to a sticky pasty condition; and articles such as those above described should not be worn near the skin, as the products of transpiration are always of a more or less oily nature; but where sufficiently protected by under-clothing, elastic bands and braids are of the greatest convenience as articles of dress, and there is an enormous and constant sale for them.

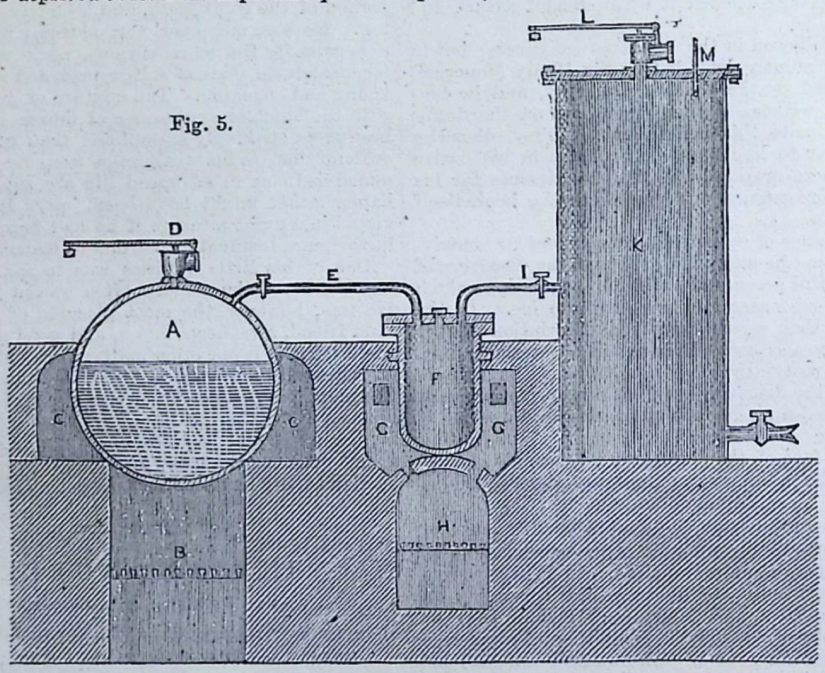
Indian rubber is also deprived of its most important qualities by a prolonged exposure to sunlight, especially when in a dry state. This appears to be the result of a gradual oxidation of the article, which converts it into a soft, sticky, resinous mass. Five hundred grains of virgin caoutchouc, cut into the form of a tape, after being exposed in a bottle with the mouth downwards, increased in weight fourteen grains in the course of nine months "by absorption of oxygen, and had become brown, soft, and sticky, especially in those parts most exposed to light. It gave up 11·81 per cent. of an oxidised, soft, and viscous resin to alcohol." The analysis of the resin was as follows:

Carbon	67·23
Hydrogen	9·54
Oxygen	23·23
	100·00

Similar samples exposed to diffused light for the same period under fresh and salt water absorbed a certain amount of moisture, but were not altered in chemical composition, nor had lost any of their original properties. The action of the sunlight upon masticated rubber was even more strong, the tape exposed only to diffused light being reduced to a viscous lump yielding to alcohol 12·64 per cent. of resin, while a similar one kept in the dark yielded only 2 per cent. of resin, and was not affected in its tenacity and elasticity. A similar piece of masticated rubber immersed in fresh water, open to the air and diffused light, gained 87 per cent. in weight, and had lost all its valuable properties; while another similarly exposed to the light and air under sea-water only gained 5 per cent. in weight, and had become slimy merely to a slight degree. Though anticipating the whole subject of the vulcanisation of rubber, it may be as well to add here, that experiments made at the same time upon the vulcanised article show—"1st. The sheet exposed in the netting to the sun and rain had lost 2 per cent. in weight: it was scarcely less tenacious than at first. 2nd. A similar sheet in fresh water absorbed 19 per cent., but was not otherwise altered. 3rd. A similar sheet in sea-water was rather more slimy, and had only gained 1·6 per cent. in weight." These experiments were made by order of the Committee of the Privy Council for Trade and the Atlantic Telegraph Company, as being a matter of national interest since the laying of deep-sea cables has been achieved.

This naturally leads us to consider the application of caoutchouc to submarine telegraphy. It has been already mentioned that it is a non-conductor of electricity, as well as impervious to water, especially when salt, so that it possesses the very qualities required in an insulator for a wire which has to be submerged at the bottom of the sea. It may perhaps, however, be scarcely equal as an insulator to gutta-percha and some patented preparations, when subjected to great pressure—more particularly is this the case if the rubber has previously undergone mastication. The process of coating the telegraph wire usually consists in cutting the material into long tapes, winding them round the wires, and consolidating them either by heat or the use of solvents. These make a perfect join for a time; but it not unfrequently happens that after a while indications become apparent of the insulation becoming imperfect, which of course impedes and ultimately prevents the passage of the signals.

Fig. 5.



Useful as caoutchouc is in its natural state, it has been rendered ten times more so by the discovery that at certain temperatures it will combine with sulphur, and yield an article which shall possess its most important properties in an increased degree, and at the same time be deprived of some of those which limited the applications of the original substance. The transformation thus caused is now known by the name of vulcanisation.

This process was discovered about the year 1843, in which it was patented by Mr. Hancock. The American manufacturers claim, however, to have made and used the vulcanised rubber at a prior date, but they did not patent it till subsequently, and that of Hancock was held valid in our law-courts when the questions of originality and prior publication were raised. The original patent rights are now, however, mere matters of history, as they have expired by efflux of time, and the trade is therefore quite open as far as they are concerned.

The first vulcanised rubber was made by melting a quantity of sulphur in an iron pot, and dipping pieces of the pure article into this bath until they had become permeated by the sulphur to their centre. When this step of the process was complete was ascertained by cutting the pieces open, as the sulphur deprives the rubber of its dark colour. The temperature of the bath was then raised to 270° or 280°, and after about an hour's exposure to this increased heat the vulcanisation was effected. In such primitive apparatus as was used at first the temperature of the bath could not be regulated with any great nicety; the sulphur near the bottom of the pot was of course much hotter than that at the surface, and so the pieces of caoutchouc which were lowest were exposed to greater heat than those above. This was found to lead to very different results, and showed that the character of the product could be completely altered by the use of a greater or less amount of heat. Thus, while the upper portions of the vulcanised rubber were pliable and highly elastic, the lower were converted into a hard, horny substance, only slightly plaible, and altogether devoid of elasticity.

In manufacturing the article for use, it is necessary, therefore, to be able to regulate the temperature to a nicety, and to have it distributed equally throughout the bath, so that the workman may ensure a certain result and a uniformity of character throughout the entire piece of material. A very convenient arrangement has been adopted at some works for using high-pressure steam as the heating power, by which means the temperature throughout the vulcanising chamber will be uniform, and can be regulated with the greatest precision.

Fig. 5 will show how the operation is conducted by means of steam. A represents the cross section of a boiler set over the fire-place B, the flues from which, C C, traverse it on both sides. At D is the safety-valve, and at E a pipe furnished with a stop-cock leads from the boiler to a small vessel F, which contains the sulphur or sulphurous ingredients. This is heated by the flues G G, which pass from a second fire-place situated below at H. A second pipe, I, similarly furnished with a stop-cock, communicates between this vessel and the large one, K, in which the caoutchouc to be operated upon is placed. This receiver is also provided with a safety-valve, L; a thermometer, M, for watching the temperature; and at the bottom a tap for drawing off the condensed vapour. Steam having been got up in the usual way, the pressure upon the valve D is so adjusted as to raise the steam to a temperature of 270° Fahrenheit, or such other as may be required. As soon as that is indicated, the fire at H is lighted in order to volatilise the sulphur contained in the vessel F. The stop-cocks in the two connecting pipes E and I are then turned on in succession, the caoutchouc to be vulcanised being already placed in the receiver K, so that the sulphurous vapours evolved in the vessel F are carried forward by the steam admitted from the boiler into the ultimate receptacle. At first the steam which passes into K is almost pure, and this serves to warm up the receiver and its contents to the required temperature; but as the sulphur vapours begin to be evolved in the vessel F, they of course pass on with the steam and envelope the caoutchouc. The thermometer in the top plate of the receiver will show whether the temperature desired is maintained throughout the operation; and if it should show signs of falling, it can be at once adjusted by increasing the pressure on the valve D, or *vice versâ;* and after a period varying usually from half an hour to two hours, according to the thickness of the material operated upon, and the degree of vulcanisation which is desired to be given, the conversion of the rubber will be complete, and the operation is stopped. The fires are then withdrawn, the stop-cock closed, and the steam let off through the safety-valves, after which the vulcanised rubber is taken out of its receptacle.

In this process heat and time are, to a certain extent, interchangeable commodities. Thus, to adopt the words of Mr. Hancock's own patent, "If sheet caoutchouc one-sixteenth of an inch thick is continued in sulphur at 350° to 370° from ten to fifteen minutes, the change before alluded to is produced; or, instead of so high a temperature, the sulphur is raised only from 310° to 320°, and the caoutchouc immersed in it from fifty to sixty minutes, the result will be much the same; and if continued for two hours at the same temperature, the effect will be proportionally increased; and if continued longer, the caoutchouc becomes of a darker colour, and nearly loses its property of stretching; and if carried still further, turns nearly black, and has something the appearance of horn, and may be pared with a knife similarly to that substance."

The sulphur may be applied in various other ways than those already described. It may be blended mechanically with the caoutchouc by working them up together in the masticator, the sulphur being first finely powdered; the heat evolved in the course of the mastication will suffice to produce the required change; or it may be done by dissolving up the sulphur in one of the solvents of Indian rubber, such as boiling oil of turpentine, and then treating the rubber with just so much of this compound as will impart to it the requisite amount of sulphur in the subsequent evaporation of the oil.

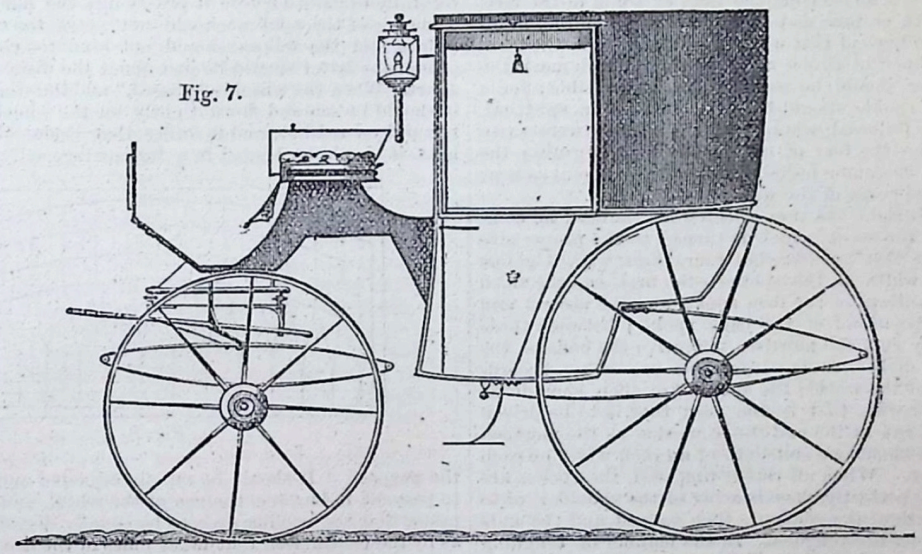
ENGLISH CARRIAGE-BUILDING.—III.

BY A LONDON COACH-BUILDER.

SPRINGS AND THEIR OFFICE—WHEELS—METHOD OF MAKING WHEELS—PUTTING ON AND VARNISHING LEATHER—FIRST STEPS IN COACH-PAINTING.

If the body of a vehicle be mounted upon the carriage without springs, it will require a greater power to draw it than if the springs were added. The load which the body constitutes is a mere dead weight, the tendency of which is to remain motionless, and therefore to resist the power that draws it. This would be particularly experienced on a rough road, or in ascending an incline, for, wherever an obstacle presents itself, the power of this *vis inertia* becomes greater. After a carriage has been once set in motion upon a smooth and level road with any given velocity, its motion, so long as that velocity is continued, will neither be retarded nor promoted by its *vis inertia;* but whenever it passes over any height, not only the weight of the carriage must be lifted, but the *vis inertia* of that weight in a new direction must be overcome. Now, by placing springs beneath the load, it becomes, as it were, quickened into life and activity, and has a tendency partially to assist instead of entirely to resist the motive power that draws it.

Fig. 7.



If this fact were fully recognised, it would be seen how great is the necessity of giving to the springs of a carriage the maximum amount of elasticity, and far more attention would be paid to that part of carriage-building than it receives at present. But what we have said is sufficient to show the vast necessity of using the best steel for the manufacture of springs, and we know of no better than that which issues from the firm of Messrs. Oxley, of Rotherham, a firm which is well known throughout the carriage trade of England.

The spring in general use for pleasure carriages is elliptical in form, and consists of several plates, the number varying according to the substance of the steel and the strength required. The plates are fitted to each other, and being forged to the required span are held in position by studs. Each plate should fit exactly to the other, and the whole when together should present a graceful sweep, at once pleasing to the eye, and perfect in form.

It might appear to the uninitiated that all this could be done

by the ordinary smith, but spring-making is a separate and distinct branch of industry, and requires great skill in the process of forging and fitting, and more especially in the process of hardening. For this purpose a peculiar fire has to be made, in which each plate has to be heated to one regular heat from end to end, after which it has to be plunged into a cold bath, and the experienced eye of the spring-maker detects, in the manner of cooling, whether the steel is properly tempered or not. If the steel be rendered either too hard or too soft, a great deal of its elasticity will be destroyed.

The wheels should be made with a due regard to the duties and offices they have to fulfil; but we are inclined to think that very little thought has been devoted to this branch of industry. The original idea of a wheel was that of the roller, whereon to place heavy loads, to facilitate their movement from place to place. Mechanical genius of the time of the Pharaohs saw the advantage of lightening out the mass, and produced a piece of mechanism circular in formation, which was supported by struts radiating from a central block. This was the first form of a framed wheel, and it has undergone slight modification; the wheel of modern days is the same in principle, but less clumsy in appearance. The mode of constructing it is as follows:—

First, the timbers should be well and carefully selected, the stock or hub, which is sliced from the limb or trunk of the tree, should be in growth as near as possible the size required, needing little reduction beyond that which it will receive in the turning-lathe. The object of this is that the rings which mark the grain of the timber should be as unbroken as possible; for a similar reason the spokes should be cleft, because in splitting, the grain must be followed, whereas, if the spokes were sawn out, there would be the fear of sawing across the grain; the felloes which form the outer periphery should also be cut as near as possible with the grain of the wood.

When the wheelwright has thus selected his timbers, he commences work with the stock, which is turned to the proper size and shape; round this he describes four rings, with a gauge answering to the width of the spokes—the first and the third rings mark the positions of the face spoke, and the second and fourth rings the positions of the back spoke; between these lines he alternately cuts the mortises to receive the ends of the face and the back spokes, twelve or fourteen in number, according to the height of the wheel; the spokes are then shouldered down slightly taper-wise, that is, the part that is to be driven into the stock is cut at the end the same size as the mortise-hole, and tapers to about one-sixteenth of an inch wider on each side at the shoulder. When all this is prepared, the spokes are driven home to a perfectly close bearing of the shoulder, or to the stock, the length of the spokes is then gauged, and the ends that enter the felloes are tongued. In the manner of tonguing spokes there is a good deal of difference of opinion among wheelwrights; that the tongue in size should be slightly in excess of the hole in the felloe that receives it, most are agreed, but a difference of opinion exists as to length.

One of the difficulties in making light carriage-wheels is to get the spoke to fit tightly into the felloe without splitting it; and the manner of accomplishing this is not by making the tongue of the spoke so large that of itself it will hold tight in the felloe, but by slitting the end of the tongue after the felloe is drawn on to it, and wedging it up. To effect this properly, some wheelwrights will say that the tongue of the spoke should be cut longer than the depth of the felloe, from inside to out, others that it should be cut slightly shorter. To us it appears of very little consequence one way or the other, so long as the end of the spoke be not allowed to project beyond the outside of the felloe. After it is made and ready for the tire, there should indeed be a little clearance between the end of the spoke and the outer surface of the felloe, for when the tire comes to be put on it draws all the felloes up into their proper position, and if in doing so it should press on the end of the spoke, the spoke will most likely be crippled.

When the wheel is so far progressed with, it is laid on the ground, and the felloes ranged round it in the order in which they are to be fitted. It is of the greatest importance that the holes be bored in the felloes to receive the spokes so as to range in an exact straight line with the mortise-hole in the stock; if it does not, the spoke will have to be strained out of the straight line in order to get it into its position; this will put an undue pressure upon it, and in all probability the wheel will not be long in wear before that spoke breaks off short in the felloe. The exact position of the hole in the felloe must therefore be obtained, and it must also be bored perfectly true to the line represented by the spoke. As the wheel is constructed very much on the principle of the arch, it is considered that by giving a number of joints to the outer rim, its strength is increased, and the number of felloes which form this rim is decided by the weight of the wheel. For a brougham the felloes of the hind wheels should be seven in number, and for the front ones six, and each felloe should be bored to receive two spokes. To connect the felloes with each other, a dowel or pin is cut at one end of each felloe, and a hole bored at the other, the pin at the end of one felloe being made to fit in the hole at the end of the other. In badly-constructed wheels the ends of the felloes are simply bored, and the pins that hold them together are driven in in the form of plugs. This process involves less time and trouble than cutting down the end of the felloe so as to have the pin in the solid with it, but the felloes of a wheel so put together will soon discover their weakness by slipping out of their true position, or what is technically called *dropping*, yet this dropping of the felloes will equally take place when the pins are cut in the solid, if they do not fit tightly and perfectly in the holes bored to receive them.

When the wheel is framed together, it should be minutely and carefully examined before it passes into the hands of the smith. The ends of the spokes should not press too closely on to the felloes, and the felloes should not bind too closely upon each other; the latter should be just about the distance of a saw-cut apart. When the wheel is "passed," and the stock-hoops put on, it should be screwed down tightly on the wheel-plate, and the tire put on red-hot, and in order that it should be at an even heat, it should be heated in a furnace specially constructed for

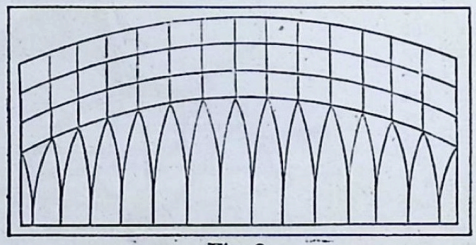


Fig. 8.

the purpose. It should be rapidly adjusted and rapidly cooled, to prevent it burning the rim of the wheel, and care should be taken that the cooling process be equally distributed all round, as by the contraction that takes place in the iron, an irregularity in this respect may be caused, which will be to the detriment of the wheel. The next thing is to rivet the tire on, and the wheel is completed. The tire should press equally at all parts of the wheel, and draw all the joints closely up, and it should be riveted on with a rivet at each side of the felloe-joint.

We have been thus minute in describing the structure of the wheel, because on this part of a vehicle so much depends, for however mechanical contrivance may distribute the wear and tear over the different parts, it all at last concentrates on the wheel; it is highly necessary, therefore, that the greatest pains should be taken in its construction. We have said that very little thought appears to have been given to this branch of industry, and we might advance argument and illustration to prove that the principle on which wheels are at present constructed is not sound, but it is no part of our purpose now to enlarge upon this or any other particular department in carriage-building. We will remark, however, that the stock is not necessarily the foundation whereon to build a wheel, and further, that there are many objections to its being so constituted. In the first place, when its centre is all scooped out for the reception of the axle-box, and its sides are mortised to receive the ends of the spokes, it is nothing but a mere shell. Every mortise-hole is more or less a receptacle for water, which the best workmanship cannot wholly exclude, and as one part of the stock is certain to be more porous than another, that is the part that will soonest absorb wet and begin to decay. If, therefore, the stock could be dispensed with, greater durability would be ensured.

A thoughtful inventor, turning these things over in his mind,

has during the last few years produced a wheel of novel construction, which is found practically to be superior to the one in common use. All the spokes, instead of being shouldered down to enter the stock, are made taper-wise, or rather wedge-shape at that end, and instead of the wheel being constructed from the centre to the felloe, it is constructed from the felloe to the centre. Every felloe is made and fitted with its two spokes, which, as they converge towards the centre, press upon each other in such a manner, that when the whole periphery is put together, a solid centre is produced by the spokes themselves, as represented in Fig. 8; so that, instead of being dependent upon a wooden stock, the spokes are dependent upon each other, and by being tightly wedged together create a mutual support and resistance; the whole are firmly secured by two metal flanges, one at the back, and one at the front of the centre of the wheel, which are tightly screwed up, by which means the greatest possible amount of solidity is obtained for the entire structure of the wheel.

This invention is due to Messrs. McNeile Brothers, of the Patent Steam Wheel and Axle Company; and it is a significant fact that wheels similarly constructed have, for a considerable time, been adopted in the Royal Artillery; moreover, they have been extensively tested on street cabs, heavy carts, and hack carriages, and, so far as we are aware, have invariably maintained their character for superiority. For ourselves, we can see that wheels so constructed must possess some peculiar advantages. There is no stock to rot, and the wheel cannot in any sense be spoke-bound, as is frequently the case in wheels of ordinary construction, by the mortise in the stock and the bore in the felloe not ranging in a true line with the spoke. In the growing desire to produce wheels of light construction, great efforts have been made of late years to reduce the size of the centre, and the inventors of these wheels have obtained this object in a pre-eminent degree. At the centre their wheels are exceedingly light and ornamental in appearance, and to render them still more uniform, they have shortened the arm of their axles, and consequently curtailed the length of the axle-box, so that there is the smallest possible projection at the centre of the wheel. At the same time, all the advantages and peculiarities of Collinge's principle are retained. In the ordinary Collinge's axle, the bearing is not upon the whole length of the arm; and practically speaking, Messrs. McNeile have in their axles cut out all that part which is useless in this respect, so that although their axle-arm is considerably shorter, the bearing is the same as in Collinge's axle of the ordinary construction.

We have now described in detail every part of one description of carriage, the manner of producing it, together with the manner of putting all these separate parts together, and we have what is familiarly known in the trade as a "brougham" complete in the wood and iron: we will next proceed to the decorative department of painting and lining, and the general finishing.

We have already explained that the roof and upper quarters of a brougham body are covered with leather. It is all important that this should adhere thoroughly and completely to the panelling over which it is strained, so as to present a solid and even surface, and it is difficult at all times to detect whether it does so or not until the painting is completed, and the gloss of the varnish renders it disagreeably apparent that it does not. This, of course, is altogether too late for such a discovery, and as there is no cure for it, we must by all means endeavour to prevent it, because if the leather be detached or become so at any point, it will then form patches or blisters, which nothing can permanently remove but stripping off the leather and recommencing the work.

Fig. 7 is the diagram alluded to in our last paper, showing an invention for throwing the back wheels further forward.

Different coach-builders differ as to the best and safest means of putting on the leather. Some advocate paste as the best adhesive material, but there is the risk of paste being either gritty or lumpy, and however slightly it may be either one or the other, the result will certainly show itself through the leather when it comes to be varnished. Glue, for this reason, is a safer adhesive material, but we consider the best material for this purpose to be smudge, which consists of the refuse from paint and varnish pots, and therefore contains a number of fatty, oily substances of a thick glutinous nature that is both waterproof and elastic. It is no matter, however, what be the means employed for the purpose of adhesion, if the leather be not properly sleeked down; every particle of air or water must be carefully expelled from beneath the leather, and in nailing it down great care must be taken not to leave hammer-marks on the surface, for such marks will show, when the painting is finished, in a series of round rings. The proper way to avoid this is never to attempt to drive the nails or pins home with the hammer, but to use a punch specially made for the purpose.

Having taken all these precautions, and left the leather for several days to get thoroughly dry, the process of painting may be commenced, and here we are beset with new difficulties. Wood, and especially leather, is of such a porous nature, that unless consolidated by some chemical process, paint and varnish will not protect it sufficiently to exclude the atmosphere totally; consequently the numerous pores are subjected to the changes of temperature, which cause them continually to expand and contract. It is highly essential, therefore, that in the surfacing process we should apply substances that retain elasticity.

There are two very important things to be studied in coach-painting. First, to form a surface hard enough to hold out the varnish and disguise the grain of the wood, and second, to have the first and intermediate coats of paint sufficiently elastic to adhere and yield to the natural action of the wood, without cracking or flaking off. In effecting one of these results we are apt to effect the other; and nothing but the utmost care on the part, both of the manufacturer of the essential ingredients, and of the person who prepares them, can ensure durability. The usual mode of proceeding is to prime over the leather-coated parts with two thin coats of black Japan, reduced with a little turpentine. The remaining portions of the body are primed with light lead colour, mixed with a little raw oil and turpentine, and a small quantity of sugar of lead to help its drying. In the next place the body receives two thin coats of colour, and the nail-holes, etc., are stopped with hard stopper, made of dry lead mixed with Japan gold size. Five coats of filling-up are next added, being mixed as follows:—

2 parts of filling-up stuff.	1 part of Japan gold size.
1 „ „ tub lead.	½ „ „ bottoms of wearing varnish.
2 „ „ turpentine.	

These five coats must be laid on in the same manner as heavy coats of varnish, one coat per day, and three additional coats of the same are generally added to the parts covered with leather. Throughout all this process, great care must be taken to keep water from the leather, to which it is very injurious, and this is one reason why it is covered with so many coats of rough stuff. The receipt here given is a standard one, and is guaranteed to rub well, and to a smooth surface.

SHIP-BUILDING.—XXIV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE OPERATIONS OF SHIP-BUILDING (*continued*).

CONTINUING the survey begun in the preceding paper, we have next to glance at the *order* in which the work of building iron ships is usually conducted; and will begin with the case of a transversely-framed vessel, with a bar keel, similar to that illustrated by the part section (Fig. 20, Vol. III., page 150).

The keel is first laid on the blocks, and the scarfs connecting the lengths are riveted up. The stem and stern-post are also generally prepared and fixed in place before the framing is begun. The preparation of the frame angle-irons, reversed frames, and floor-plates goes on simultaneously, and these parts are commonly combined and riveted together as individual frames before they are raised, the operation of riveting up being performed after the frames have been laid across the keel near their proper stations. The deck-beams are also in hand at the same time, and if not supplied in a finished form by the manufacturer they are prepared in the ship-yard, being carefully adjusted to the proper round-up, and lengths. If the vessel be of only moderate size, say from 600 to 800 tons burden, all the deck-beams are riveted to the frames before the latter are raised; and for larger ships at least one tier of beams would be so riveted, to act as cross-spalls when the frames are lifted, and to lessen the work to be done afterwards.

When this stage of the work has been reached, the finished frames, with the beams attached, lie, as we have said, across the

keel from stem to stern; and they are raised into place by means of "tackles," or "purchases," being "plumbed" and "horned" to ensure correctness of position. Various plans are followed in raising the frames, some builders beginning aft and working forward gradually, others reversing the order, and others commencing amidships and working forward and aft simultaneously. It is usual to fix a harpin near the height of the upper ends of the frames, and another at or near the height of the bilge, before the frames are raised, in order that they may be at once supported to some extent, and afterwards to add such other harpins as may be required, in order to "fair" the frames. When this operation has been finished, and the frames have been secured to the harpins, progress can be made at once with the work of fitting and riveting the keelsons, stringers, etc., in the hold; fashioning and fixing the stringers, ties, etc., on the various decks, or completing the tiers of beams not put in place before the frames were raised, and also in preparing and riveting the outside plating.

There is obviously a remarkable contrast between the ease and simplicity of the foregoing processes in building an iron ship, and the comparative difficulty and complication of the corresponding processes in building a wood ship. Of course, in the latter case the frame-timbers may not be built up in place piecemeal on the plan described in the preceding paper; but the two bends in one frame may be put together on the ground and raised bodily, and this is done in many cases. But even under these circumstances the beams cannot be combined with the frames before they are raised, as they can be in an iron ship; and temporary cross-spalls, as well as other struts and ties, have to be fitted to prevent change of form in the frame when it is being raised. Moreover, the shelf-pieces and clamps have to be fitted in the wood ship before the beams can be put in place, and other works must be performed before much progress can be made upon the decks. It is noteworthy, too, that the fastening of the outside plating need not be deferred until the inner works are performed, but as soon as the plates are fixed they can be riveted and caulked. In this respect also time is gained upon the wood ship.

Respecting the remaining works on an ordinary iron ship little need be said. The bulkheads are usually prepared and fitted together outside the ship, and afterwards put in place and riveted up. The fitting of subordinate parts of the structure, in the hold and on the decks, is proceeded with as seems best under the circumstances of each particular case; and according to the urgency of the work and the number of men employed upon it, so would its order be regulated.

It should be fully understood that the description given above is only intended to illustrate a common method of conducting the work of iron ship-building, and one which seems, on the whole, preferable to other plans, when the transverse system of framing is used, although it is by no means universally adopted. For example, instead of putting the frames and beams together before raising them, many builders prefer to put the *frame angle-irons* in place separately, and to fair them by harpins, before combining them with the floor-plates and reversed frames, which latter pieces are subsequently put in place and riveted to each other as well as to the frame angle-irons. After this has been completed the beams are got in, and the remaining portions of the work are proceeded with much as on the other plan.

There can, we think, be no question that the work of riveting up the various parts of the frames, and of attaching the beams thereto, can be performed more readily and expeditiously before the frames are raised than afterwards, and the main argument advanced in favour of the plan of raising the frame angle-irons separately is that they can then be *faired* with ease, whereas when riveted to the reversed bars, floor-plates, and beams it is most difficult to adjust them. There is doubtless some force in this argument, seeing that in an iron ship correctness of form can only be ensured by fairness in the framing as prepared, no operation corresponding to the "dubbing out" or "reconciling" of a wood ship's frame being possible. With care, however, on the part of the draughtsmen who prepare the curves to guide the workmen in bending the frames, and care also in the conduct of the latter operation, it seems possible to secure an amount of fairness in the frames sufficient for all practical purposes when they are put together before being raised; and in view of actual and extensive proof of this fact, it seems, as we said before, preferable to use that method of construction.

In passing, it will be sufficient to say respecting the order of the work on ordinary composite ships that, so far as the framing, longitudinal strengthenings, fitting of deck-beams, and the remaining iron portions of the structure are concerned, the plans followed are identical with those described above for transversely-framed iron ships. Special methods are, however, required in fitting the wood keels, stems, and stern-posts; and before the outside planking can be worked the iron bilge and sheer strakes, as well as the diagonal ties, must be fixed and riveted upon the outside of the frames.

Longitudinally-framed iron ships have to be constructed on plans differing considerably from either of those described; and to illustrate the method of procedure we will glance at that adopted in building an ironclad on the bracket-frame system, as shown in section by Fig. 23, Vol. III., page 224.

The flat keel-plates and vertical keel are first prepared and fixed in position on the blocks, the amidship portion being put in place first. A tier of the short transverse frames (F F), with the brackets (B B) attached, is then put in place amidships, their positions having been previously indicated on the vertical keel-plate. The heels of these frames are temporarily secured to the vertical keel, and under their heads a ribband is secured, and shored, just like the lower harpins H in Fig. 63, page 189. Next the amidship plates of the lowest longitudinal frame (L in Fig. 23) are fitted to the heads of the short transverse frames, and temporarily secured. Another tier of short transverse frames is then put in place above this longitudinal, and under the heads of this tier also a ribband is fixed, after which a second longitudinal is fitted, and so on until the uppermost longitudinal, forming the armour shelf, is reached. The plan will therefore be seen to be very similar to that followed in framing a wood ship, when the timbers are raised singly; and the remarks made in a former paper as to the difficulties attaching to the construction of iron ships with longitudinal framing, as compared with those having only transverse framing, will be seen to be well founded. At the same time, the great advantages in point of structural strength resulting from the use of longitudinal frames must not be forgotten.

During the time occupied in carrying up the various tiers of frames amidships, the framing is also being extended forward and aft, and it is advantageous to follow this order, because a considerable time is usually required to prepare the massive forgings forming the stems and stern-posts of these vessels, so that the framing of the bow and stern must necessarily be left incomplete for some time. Reverting to the amidship portion, the next stage in the work of framing is fixing the continuous reversed frames (C C), and hoisting in the vertical frames behind armour. This completes the operation, with the exception of the trifling fairing generally required, and the frames behind armour are usually secured in place by means of ribbands and cross-spalls, similar to those fitted to the top timbers of a wood ship.

Nearly all the parts of the framing have consequently to be riveted up after being put in place, and until a considerable portion of this work is finished the outside plating cannot be commenced. The fixing and riveting of the inner skin depends largely upon the completion of the outside plating, and is undertaken when convenient. The skin-plating behind armour, and some other parts of the work, are not dependent upon the completion of the lower portions of the structure, and are pushed on separately. The deck-beams are also prepared and put in place as soon as possible, in order that the work on the decks—plating, planking, and framing hatchways, etc.—may be commenced. Bulkheads and other arrangements in the hold are also undertaken as soon as the inner skin is sufficiently advanced.

Throughout the construction of the ship the work amidships is farthest advanced, and it is at that point that the first wood backing behind armour and the first armour-plates are secured. The operations of bending these massive plates to their proper curvature, planing the edges and butts, drilling the bolt-holes, and fixing the plates on the ship's sides, are all worthy of separate treatment; and we regret that the space at our disposal is so limited as to prevent us from describing them, or indeed from giving more than the barest outline of any of the operations of ship-building.

COTTON-SPINNING.—I.

By J. Robertson.

THE FACTORY—ARRANGEMENT OF THE ENGINES—SCUTCHING OR BLOWING-ROOM — MIXING — GINNING — SCUTCHING MACHINES.

The art of cotton-spinning embraces not merely the single process by which the raw material, previously prepared, is finally converted into thread, but essentially all the preparatory operations.

The cotton factory, as it is now almost invariably constructed, and apart from the architectural ornamentation which not unfrequently is found tastefully combined with it, is a huge block of four or five storeys in height, and from eighty to one hundred feet in width. This excessive width is easily accounted for. The experience which has been obtained in this branch of industry has led spinners to adopt, as a rule, mules containing 700 to 900 spindles. Many years elapsed after their introduction before this number was thought practicable; gradually, however, as improvements developed the powers of the machine, it was found possible to exceed this very considerably. Mules of 1,100 and 1,200 spindles have been worked. But yet the number already specified as being fixed upon by practical men, is found in every way to give the greatest satisfaction. The cost of maintaining the machines and the cost of attendance is, in this case, at a minimum. Now as the rove creels which stretch along the back of the mules, and stand about six or seven feet high, would seriously interfere with the light were they placed longitudinally, they must be placed across the building. The full benefit of the side windows is thus obtained, and an uninterrupted flow of light is permitted along the whole of the mule. As a necessary consequence of this extreme width, and the need of abundance of light, a great improvement upon the old style of building has been made, as regards the height of the ceiling. Formerly a height of nine feet or thereabouts was considered amply sufficient for this purpose, whereas now it is commonly fourteen or fifteen feet, a difference which must exercise a favourable influence on the health of the operatives.

The first storey is generally set apart for the preparation-room, which is in some cases supplemented either in the second storey or by a side shed. Here the carding-engines, lap-machines or doublers, drawing-frames, and roving or fly frames are systematically arranged, so as to economise labour, and prevent confusion when the cotton in process is intended for yarns of different "counts" or "numbers." At this point, it may be explained that yarns are designated according to the count, or number of hanks of 840 yards, in each pound weight. Thus, yarn having thirty hanks per lb. is called No. 30, forty hanks per lb. No. 40, and so on.

The "scutching" or "blowing" room is most frequently a detached fire-proof building, on account of the danger which arises from stones, metal, and even more inflammable substances, carelessly packed along with the cotton, coming into contact with the rapidly revolving heaters, and thus igniting the fibres. The size and arrangements of the blowing-room are dependent upon the quantity of cotton to be passed through it, and various other considerations. All the departments in which the different operations of preparing or spinning are carried on, are heated by means of steam-pipes to an uniform temperature of about 75 degrees.

The aim of the cotton-spinner is to strike the quality of yarn suitable for the market, and to maintain uniformity in this. In consequence of the difficulty of obtaining uniformity in the quality of cotton of even the same class, and the multiplicity of the operations through which it has to pass, in any one of which defective machinery or negligence on the part of the attendants has a very prejudicial effect, this is no easy matter; indeed, anything more than an approximation to uniformity is impossible. To obviate as far as practicable the difficulties arising from this accidental difference of quality, is the object of the first manipulation to which the cotton is subjected. This is *mixing*. The method usually adopted is to spread out the contents of a considerable number of bales in thin layers, one above the other, until a great pile is formed, from the side of which the raw material is taken to the first machine.

It is not to be supposed that a "mixing" of cotton is always necessarily of the same *class*. Generally speaking, the lower numbers are made entirely from East Indian, or other low class cotton, medium counts from American, and the higher from Egyptian or good American. Intermediate numbers, however, are very frequently made from a "mixing, which embraces several kinds of cotton in varying proportions, according to the judgment of the spinner.

This first manipulation then having been accomplished with a considerable amount of care, the raw material is sufficiently analysed in staple, strength, and colour, to be passed on through the various stages by which, ultimately, it becomes converted into finished yarn.

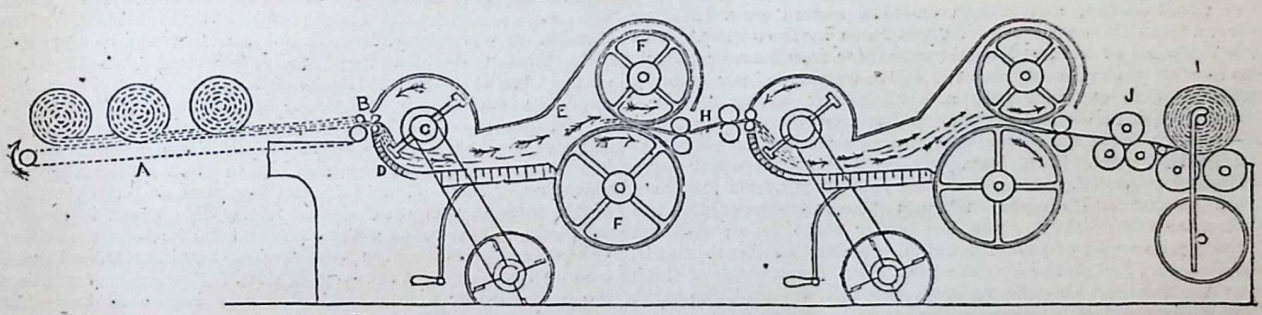


Fig. 1.—SECTIONAL VIEW OF FIRST SCUTCHING MACHINE.

Before leaving the hands of the planter, the cotton is subjected to a rough cleaning process called "ginning," by which the seed is stripped from it. This, however, leaves a large quantity of broken seeds, leaves, sand, and other impurities. In this state it is packed in bales, and pressed into the smallest possible bulk, for convenience in carriage, by means of steam or water power. On opening out the bales, it is found that the cotton has become caked and clotted in consequence of the excessive pressure to which it has been subjected. To loosen the fibres, and to render them soft and flocculent, as well as to separate them from extraneous matter, is the object of the first process. This is usually accomplished by means of the "opener."

This is a very simple machine, very much of the nature of a threshing-mill. It is of various construction, different machinists carrying out their own ideas as to the most suitable arrangement for effectually loosening and opening the fibres without injuring the staple, or making unnecessary waste. The main features of all, however, are similar. The cotton is passed into a circular enclosure, partly formed by a grid of angular iron bars, inside of which revolves an iron cylinder covered with teeth. These teeth strike the fibres with great violence, throwing the foreign weightier matter out between the bars of the grid, and loosening the fibres themselves, which then float forward against a perforated zinc or wire cylinder, from the interior of which the air is exhausted by means of a fan. The dust and sand which have been set free by the beater, pass through the cylinder with the blast, and are lodged in a chamber beneath, or are thrown into the atmosphere. The cotton is discharged by the revolving cylinder or dust-cage in a soft and downy heap.

In some machines there are several toothed cylinders, which successively operate upon the fibres as they pass through,

Though usually the toothed cylinder lies in an horizontal position, there is a very excellent "opener" in which it is vertical, and of a conical form, with the small end of the cone at the bottom. Being surrounded with a conical grid, the cotton which enters at the bottom ascends spirally and passes to the dust-cage from the top. It is obvious that there must be a greater likelihood, by this arrangement, of the weightier ingredients which are mixed with the cotton gravitating through the grid, and not being carried along with the cotton fibre itself.

The "opened" cotton is next taken to the first *scutching*-machine, with the object of being still further separated from sand, seed, leaf, etc. Here it is spread in a uniform layer upon a travelling lattice or feed-table, a certain fixed weight of the cotton being spread upon a certain space. Great care must be observed in this operation, otherwise it will be impossible to produce yarn of uniform weight or size. A new method of obtaining accuracy in this department has been largely introduced of late years. By means of levers worked by the upper feed-roller, and operating upon a belt connecting two conical drums, a varying motion is given to the lattice. Then, when the feed-roller rises in consequence of the cotton being spread too thickly upon the feed-table, its motion is at once retarded; and on the other hand, when the roller sinks on account of there being little cotton passing under it, the speed is accelerated, so that more is immediately brought forward to supply the deficiency. This is found to work with wonderful accuracy. The cotton having been placed upon the feed-table, is carried forward by it until it is taken hold of by a pair of toothed or fluted rollers, and passed on to a second pair. Issuing from these it is struck with great force by the *beater*. This is composed of two, and sometimes three iron bars or blades, going at the rate of about 1,500 revolutions per minute. Above, it is enclosed with a semi-circular casing of sheet iron, whilst under the point at which the cotton enters, and concentric with the circle described by the blades, there is a grid of narrow iron bars. These have their upper edge slightly projected, so that seed and leaf struck from the fibres are caught and directed through the interstices into the receptacle beneath. From the beater there is an enclosed passage to a pair of perforated zinc cylinders similar to that in the opener, and as the air exhausted from the interior of these by the fan can only be replaced through the grid, the light fibres cannot follow the weightier ingredients, but float loosely forward with the draught until they impinge against the cylinders. Whilst the dust freed from the cotton is sucked through the perforations and thence thrown into the atmosphere, the cotton itself is rolled out between the cylinders, and by a second series of toothed rollers carried forward to a second beater and pair of dust-cylinders. It is now finally delivered in the form of a felted web, to which cohesiveness is given by compressing it with one or more calendar rollers before being wound up in the form of a large bobbin or *lap*. By referring to Fig. 1, in which the outlines of this machine are shown in section, the reader will be better able to understand this process. A is the travelling endless lattice upon which the cotton is spread, B the feed-roller, C the beater, which is also shown longitudinally in Fig. 2; D the grid of angular bars, E the enclosed passage through which the fibres float, having a grating with a false bottom, into which the refuse falling is retained until removed at regular intervals; F are the dust-cages, H the rollers which carry forward the cotton to the second beater and dust-cylinders, J the calendar roller, and I the finished *lap*.

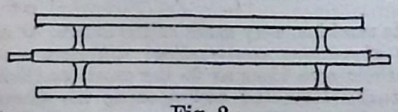


Fig. 2.

As the cotton in this state is still far from being thoroughly purified, the laps are taken to the second scutching-machine, similar in almost every respect to the one already described. To equalise the weight and quality of the raw material, three laps are placed upon the feed-table, and are unwound simultaneously. To render the lap produced by this machine equal in thickness to one of those which feed it, it requires the dust-cages to deliver at three times the rate at which the feed-rollers take in the cotton. Usually the second scutcher has but one beater and one set of dust-cylinders.

Though the raw material is now comparatively free from seed, husk, leaf, etc., there are still remains of these impurities, which it is absolutely necessary to separate from it. The fibres also which are irregularly jumbled together in the lap must be laid parallel, and those which are too short in staple thrown out. All these objects are obtained in the next process—*carding*. This is by far the most important of all the preparatory operations, the quality of the yarn being dependent, in a great measure, upon the care and skill with which it is conducted.

SEATS OF INDUSTRY.—XXXV.

SAN FRANCISCO.

BY WILLIAM WATT WEBSTER.

San Francisco, the principal town in the State of California, although not the capital, is the largest and most important commercial city on the western shores of North America, and well entitled to be called the Queen City of the Pacific. It is one of the most modern of the great trading centres of the world, and it is a notable instance of a town that owes its creation and rapid growth to the discovery of gold in its immediate vicinity; but its natural advantages for the prosecution of commerce, and the fertility of the adjacent country, would suffice to maintain its prosperity, although the gold deposits of California should become exhausted. There is evidently a great future before San Francisco, and its past history possesses a peculiar interest.

A mission of St. Francis of Assisi, frequently called Dolores, was established near the site of the present city in 1776, by two Spanish monks named Francisco Palou and Benito Cambon. This mission devoted itself to agricultural pursuits, and amassed great wealth in flocks and herds. In 1825 it had under its care 1,800 Indians, and possessed 76,000 cattle, 79,000 sheep, and 3,034 horses, besides a vast amount of other kinds of property. For upwards of half a century the mission flourished in unabated prosperity, but in 1834 the country was placed under the control of the civil powers, and the property of the mission was secularised. After this event it rapidly declined. There were a few huts built of adobe (sun-dried bricks) scattered along the borders of the bay in 1830, and small trading vessels were at that early date in the habit of visiting the port once or twice a year, for the purpose of bartering manufactured goods for hides and furs, with the Spanish settlers, the Indians, and the Vaqueros, or half Indians, who inhabited the district. Among the first undertakings of the civil authorities, who wished to encourage colonisation, was the construction of a village called Yerba Buena, near the site of the present town-hall of San Francisco. The first house was erected in 1835, by an agent of the Hudson's Bay Company, and the first survey of streets and town lots took place in 1839. It is known that gold had been found in California about this date, and it is surmised that the Mission Fathers were aware of its presence. In 1842, Don Abel Stearns sent some ounces of gold to Washington, that he had obtained from an Indian; but it was not till four years later that the precious metal was discovered in any quantity. An American man-of-war entered the bay in 1846, and took possession of the place in the name of the United States; and at the conclusion of the war then in progress between the United States and Mexico, California passed into the hands of the republic. Up to 1847 the town was known as Yerba Buena, but in that year the *ayuntamento*, or town council, changed it to San Francisco. The population at this time numbered only 450. When rich gold deposits were found at Fort Suttee in 1848, and the actual gold fever set in, the town was for a brief period nearly deserted, but at the approach of the wet season it was crowded as it had never been before. So instantaneous was the effect of this discovery on the fortunes of the place that, in the following year, San Francisco sprung into a great commercial centre, and in 1850 it became a corporate city. In consequence of the rush of adventurers from all parts of the world, the price of everything rose to an almost fabulous height, and the assessed value of real and personal estate in the city for 1850 amounted to 21,621,214 dols. In consequence of the inability of the municipal authorities to protect life and property, a vigilance committee was organised by the inhabitants in 1851, and several criminals were executed; and again in 1856, Lynch law was reduced to a system in San Francisco.

As a town, therefore, San Francisco is little more than twenty years old. By 1860 its population numbered 56,802; in the census of 1870 the population is returned at 149,473; but according to Mr. J. G. Player-Frowd, who has just published a work on California, it was found after careful research to amount to 172,750 souls, of whom 8,000 were travellers, that number, on an average, arriving in and leaving the town daily. The analysis of the census for 1870 shows the mixed character of the population, nearly one-half of the inhabitants being of foreign extraction. It was found that the city at that date contained 25,000 natives of Ireland; 13,000 Germans; 11,000 Chinese; 7,106 Britons; 3,548 Frenchmen; besides Italians, Mexicans, Swedes, Norwegians, and Swiss; and about 2,000 coloured persons. The disproportion between the sexes is a noteworthy feature of the population of San Francisco and of the whole State of California. At one period it was estimated that there were in the city from three to five men for every woman. As might be expected, from its dependence on the gold mines, gambling is the besetting sin of San Francisco, and it is believed that in the rainy season, when large numbers of miners are in the city, gambling is carried on to a greater extent here than in any place in the world. From Consul Booker's report upon the trade of the State for 1871, we learn that there are 425 factories and mechanical works established at San Francisco, which give employment to about 9,000 men and 450 women. Among these we may note 78 cigar manufactories, 34 iron foundries, 35 carriage and wheel factories, 23 breweries, 21 marble and stone works, 17 tanneries, 13 shoe and slipper manufactories, 11 grist mills, 15 soap factories, 10 saw mills, and sash and door manufactories, 5 billiard-table manufactories, 10 hat and cap manufactories, 1 silk manufactory, 2 pianoforte manufactories, 2 woollen mills, etc. The wages of artisans are very high, but the cost of living is also very great. To quote again from Consul Booker's report, bricklayers earn 20s. per day; ship-carpenters, grist-millers, masons, maltsters, millwrights, and riggers from 16s. to 20s. per day; stonemasons from 18s. to 20s. per day; house carpenters, painters, plasterers, and plumbers, 16s. per day; and common labourers from 7s. to 8s. per day without board, and from £5 to £6 per month with board. The bricklayers, stonemasons, and plasterers work only eight hours per day; the other artisans work ten. Although the wages of domestic servants have slightly declined, owing to the incursion of Chinamen, who are exceedingly handy at many kinds of domestic work, family cooks still receive from £48 to £74 per year; housemaids from £48 to £72; nurse-girls from £36 to £48; and men-servants from £84 to £110. The high price of labour is a great check to the progress of manufactures in San Francisco, and the introduction of Chinese labour still meets with formidable opposition. On the 31st of December, 1871, the savings' banks and loan societies of the city had on deposit £7,406,675, on account of 41,590 depositors, against £6,257,910, on account of 36,862 depositors, on the previous 31st of December, showing an average for each depositor in 1871 of £178 against £169 in 1870. This is a striking evidence of the prosperity of the working classes of San Francisco.

The bay of San Francisco forms one of the most spacious and safest harbours in the world, being fifty miles long, and averaging eight miles in width, exclusive of the bays of San Pablo and Suisoon. It has a coast-line of 275 miles, and the entrance, called the Golden Gate, which is little more than a mile in breadth, is deep and easy of navigation. In order to overcome the shallowness of the water close to the city, a wharf, 2,300 feet in length, has been projected into the bay, at which vessels of all sizes can moor in safety. The value of the gold exported from San Francisco in 1867 was returned at £8,330,250; but it has been estimated that the total exports of the precious metals for that year, including large sums carried by miners and others to the United States, Mexico, and elsewhere, amounted to £9,585,538. The other exports for 1867 reached a total value of £4,493,150, of which amount £1,663,730 went to Great Britain, The imports from Great Britain for the same year reached a total of £3,704,941, about one and a half millions sterling consisting of cotton, linen, and woollen goods. Among the principal articles of Californian produce exported from San Francisco in 1867 were included wheat, to the value of £1,890,540; flour, £643,473; wool, £243,100; hides, £65,800; quicksilver, £186,250; ores, £106,300; and wines, £27,400. The first shipment of wheat and flour from the port was made in 1856, and went to New York. In 1867, 35,683 passengers arrived by sea at San Francisco, and 20,419 left by sea. There were over 100 steamers employed in navigating the inland waters of California in that year, 87 of which, measuring 20,460 tons, were registered at San Francisco, and the custom receipts of the port amounted to 7,442,881 gold dollars. Regular steam communication was established with Hong Kong in that year, the voyage taking six days. One of the most notable features of the commerce of San Francisco is the rapid extension of the trade between that port and Japan, since the throwing open of the latter country to the commerce of the world, nineteen years ago; and this is a trade that is likely to increase enormously as the resources of Japan are developed, and its institutions reformed, under the new and enlightened policy of its present rulers. During the past three years a considerable decrease has taken place in the exports of gold and silver from San Francisco, the total value in 1871 being £5,908,128; and during the last two years, owing to drought, the exports of native produce have also declined. The total value of the Californian produce shipped at San Francisco only amounted in 1870 to £3,569,630, and in 1871 to £2,790,234; but in addition to the exports by sea, about £3,000,000 worth of goods were dispatched eastward from the city by rail. But notwithstanding the drought, the general trade of San Francisco during the year 1871 was very prosperous.

San Francisco is situated on a sandy peninsula which separates the great bay from the Pacific Ocean, and lies six miles southward from the Golden Gate. It is far from beautiful as seen from a distance, and the vicinity is described as desolate in the extreme. "A few scrub oaks," says Mr. Player-Frowd, "whose dwarfed and knotted branches all point away from the prevailing west wind, are to be met with at rare intervals. The *Ceonothus*, a species of privet, is the only indigenous shrub that has any pretensions to beauty. For eight months of the year a strong breeze, laden with fog, blows from the Pacific, and clouds of fine sand accompany it in its progress over the peninsula." A few years ago, during the wet season, the streets of San Francisco were puddles into which carriages sunk up to the axles, and during the dry season the dust was intolerable. But the streets have now been floored with stout planks, and a great improvement has been effected in them in both of these respects. The city is, on the whole, regularly laid out, and the houses well built, and many of them handsome; but the streets in the older quarters are narrow, and the houses mean-looking. A portion of the site is hilly, and at one corner stands Telegraph Hill, the highest eminence, which has nearly been "whittled" away in the attempt to run streets in straight lines over and across it. Several of the streets are very fine. The principal business street is Montgomery Street, a large portion of which, however, has been found too narrow for the increasing traffic, although a part of it still retains its old dignity, being occupied with the great hotels, and some of the finest shops in the city. But the best street in San Francisco is Market Street, a thoroughfare ninety feet in width, and extending for five miles in a straight line, and with a street railway running nearly its whole length. There are a large number of churches of all denominations, and several theatres in the city, including a Chinese temple and a Chinese theatre. San Francisco is moderately well supplied with schools, the expenditure for the maintenance of public schools in the city and country for the year ending June last having been about £100,000. No less than twelve daily, twelve weekly newspapers, and four magazines are printed in the city, and more than one of the newspapers are very ably conducted, and have a reputation even in Europe. Some of these papers are in German, French, and Spanish. The city is well provided with hospitals and other charitable institutions, and improvements are constantly being carried out. Consul Booker, in his report for 1871, says:—"Some very handsome residences have been built. A park, not of the most desirable character, but with the advantage of being within two miles of what may be called the centre of the city, is being laid out." San Francisco has suffered severely and frequently from fires, but the damage has always been speedily repaired, and since houses of brick and stone have been substituted for wooden houses and tents, the fires have been less frequent and less

disastrous. The water-supply of the city is barely adequate, and a project has been started for bringing the water of Lake Tahoe from a distance of 260 miles, distributing a portion to the various mining camps and towns that intervene.

MINING AND QUARRYING.—XXXII.

BY GEORGE GLADSTONE, F.C.S.

ANTIMONY.

GEOGRAPHICAL DISTRIBUTION—SULPHIDE OF ANTIMONY—ASSAYING—REDUCTION—REFINING—PROPERTIES—USES—TYPE METAL—BRITANNIA METAL—IN MEDICINE.

ANTIMONY is pretty widely diffused in Nature, especially in combination with other ores, but it does not occur in such sufficient quantity in the British Isles as to be of much importance to the miner. It is generally to be found in tin and lead ores, but it is rather regarded as an impurity than a source of profit; though several mines were worked for this metal in Devonshire and Cornwall during the past century, when the present more abundant foreign sources of supply were unknown.

The principal European deposits are found in several parts of the Austrian Empire, but Germany and France also yield sufficient to supply the reduction works of those countries. Almost the whole of that which is consumed in England comes from the mines of Sarawak, in Borneo, which were opened up by the late Rajah, Sir James Brooke. It is brought over to England in the rough, and is here reduced to the metallic state. More recently some very good samples of the same description of ore have been obtained in New Zealand.

The Borneo ore consists entirely of the sulphide, which is the commonest form in which this metal occurs. The oxide is, however, found either alone or in combination with it, in some of the European deposits. The sulphide is a very dark-grey crystalline substance, and when free from earthy matter or other metals, generally contains about 74 per cent. of pure antimony.

The simplest plan of assaying this ore is to heat a given quantity in a crucible, after having been finely pulverised, with 4 per cent. of the cyanide of potassium. Only a very moderate temperature is required for this purpose, and as the operation is quickly performed, the risk of loss by volatilisation is reduced to a minimum. The metallic antimony, which will be found in the crucible, has then only to be weighed. A more common plan, however, is to roast the ore first, with free access of air, so as to drive off the sulphur and obtain an oxide instead, and then to fuse the oxide in a crucible, with the addition of a flux. But there is considerable risk of loss in the calcining of the ore, as it is very fusible and volatile, so that great care has to be taken in keeping the temperature moderate, and the ore well stirred, until the whole of the sulphurous acid has been evolved.

Another mode, which has some advantages, though not very accurate in its results, dispenses with the preliminary calcination by fusing the sulphide itself, with the assistance of bright iron filings. The result of this will be a mass of metallic antimony at the bottom of the crucible, overlaid by another of sulphide of iron. They can be readily distinguished, as the former is white and highly crystalline, while the sulphide of iron will rather resemble bronze. The antimony has then to be carefully separated and weighed.

A much greater heat is required in this process, so that a little of the antimony is liable to be sublimed, and some small quantity will also have entered into combination with the iron itself. In order to decompose the whole of the sulphide of antimony, and at the same time to avoid the latter source of error, it would be necessary to know exactly how much of the iron to add; but that presupposes the very knowledge which it is the business of the assayer to ascertain; so that in proportioning the quantity of iron to the charge, he can only act to the best of his judgment; and according as he has added too little or too much, he will either have some sulphide of antimony or antimoniate of iron remaining. The addition of some carbonate of soda will increase the fusibility of the mass, producing a double sulphide of iron and sodium, from which the metallic antimony can be more readily separated.

The ordinary operations for the production of the metal on a large scale bear a very close resemblance to those adopted by the assayer.

There is a preliminary one to which the rough ore is subjected for the purpose of separating it from all the earthy matters mixed with it, which will have to be described. The old plan, but which is still in use in some countries, was to heat the ore in crucibles having an opening below, and a pipe connecting them with another set of crucibles ranged on a lower level. After charging them with the crude ore, the lids were luted down and the fire got up, which played freely round the pots before passing into the flue. The pure sulphide of antimony was thus melted out, and ran down the pipe into the lower crucible.

A more modern plan is to melt the ore on the hearth of a reverberatory furnace, something similar to those used in the reduction of tin, which has a considerable fall towards the centre, from which a pipe conducts the molten sulphide into a receptacle outside. About one ton of ore can be passed through such a furnace in the course of a day, which, if tolerably rich in metal, will usually yield about half that weight of the pure sulphide.

An improvement upon this was introduced at one of the Continental establishments, which will be best understood by reference to the accompanying diagrams, Fig. 1 being the horizontal section, and Fig. 2 the elevation. It consists of a vaulted furnace, A, A, A, having three fire-grates, B, B, B, between which are two chambers, C, C, closed at the ends by iron doors, D, D, with small flues, E, E, etc., leading directly from the fire-places to the chambers; several flues, one of which is seen at F, lead from the upper part of the vault into the chimney G, which is subdivided for some distance by H, so that if necessary for repairs one side only may be used, and the workmen at the other will not be distressed by the fumes. I, I are doors for getting at the several parts of the apparatus, but which are kept closed while the furnace is in use. K, K are cylinders with an aperture in the lower part for containing the ore which has to be eliquated, and L, L are the pots for receiving the pure sulphide. These latter run upon iron trucks, and are drawn out at the doors D, D, etc., when they require emptying. The cylinders stand upon tiles made of fire-clay, and are covered with lids made of the same material. Each cylinder will hold a charge of about 500 lbs. of ore, and as soon as the operation is complete the residue is raked out, and a fresh charge introduced. This occurs about every three hours.

The sulphide of antimony having been freed by one or the other of these processes from all its earthy ingredients, is put into a reverberatory furnace for calcination, which is so arranged as to supply a large quantity of atmospheric air. The temperature must be kept moderate, and the furnace-man has to stir the charge constantly, so as to expose all of it equally to the oxidising influences. As soon as the whole of the sulphur has been evolved, and the antimony converted into an oxide, the material is ready for reduction, which is done in crucibles heated in an air-furnace. The oxide of antimony is mixed with about 10 per cent. of tartrate of potash, which takes up the oxygen and leaves the metal free.

A ready plan of reducing the metal direct from the sulphide has been adopted in Germany, but the antimony produced is not of a very satisfactory quality. The sulphide mixed with a due proportion of iron-scale or filings, to take up the sulphur, and some carbonate of potash, soda, or lime, is thrown into a reverberatory furnace, and heated for eight or ten hours. The antimony will by that time have collected at the bottom of the hearth, from which it is drawn off through a pipe into a receiver. The metal thus made has to be re-melted two or three times in a crucible along with some charcoal and alkali, before it is sufficiently purified for general purposes.

The ordinary antimony of commerce is always more or less mixed with other metals, and not unfrequently contains some sulphur which has not been thoroughly expelled. The simplest plan for purifying it is to pound it up in a mortar with 10 per cent. of nitrate of potash, and then fuse the mixture, from which the pure metal will separate itself.

It is a brittle silvery-white metal, melting at 800° Fahrenheit, of no value in the arts, except in combination either as alloys or as salts.

In the metallic state it is of special importance to the type-founder, as it serves to impart to type-metal the peculiar properties required in that manufacture. A very common compound for this purpose is from 70 to 75 per cent. of lead, 20 to

25 per cent. of antimony, and 5 of tin. But sometimes a hard metal is made without any lead at all, in which case about 25 per cent. will be antimony and the rest tin. Some makers add a little arsenic, and occasionally copper; but the metal now under consideration is an invariable constituent.

Antimony, to the extent of 10 per cent. and sometimes more, is used in the composition of the best Britannia metals. Bell-founders employ it because it improves and increases the sonorousness of other metals. It is of advantage in making castings, because its presence renders other metals more easily fusible; and in making metallic mirrors it is also beneficial, improving the texture, and thus rendering the alloy susceptible of a higher polish. Other alloys which contain antimony are more particularly described in Article XVII. (Vol. III., page 148).

It forms salts with sulphur, oxygen, and chlorine, all of which are of use, especially in medicine.

The sulphide and oxide employed for such an important purpose as this are not the impure articles found in Nature, nor even the direct products of the furnace; they are specially prepared to render them perfectly free from all noxious ingredients, and especially from arsenic, which is by no means the least uncommon.

The sesqui-sulphide may be prepared by fusing 13 parts of pure antimony with 5 of sublimed sulphur in a crucible. Another plan consists in digesting the crude sulphide itself with an equal quantity of carbonate of potash, and half as much again of slaked lime in water, in a closed vessel. The solution will then contain a double sulphide of antimony and the alkali, from which the pure salt is precipitated on adding sulphuric acid, which decomposes the alkaline sulphide.

The double sulphide of antimony and potash has long been in use, under the name of kermes mineral, for medicinal purposes; but latterly it has gone, to a great extent, out of use, as it has no special quality to recommend it in preference to another more familiarly known antimonial compound, tartar emetic—the bitartrate of antimony and potash.

By adding some dilute acid to a solution of the foregoing, it is converted into the golden sulphide, so named from its brilliant yellow colour. It contains a small quantity of oxide. It is used in medicine, and is more powerful in its effects than the preceding.

Another preparation, which is also much used for similar purposes, is a compound of this metal with chlorine. The sulphide is dissolved in hydrochloric acid, with or without the addition of nitric acid. The hydrogen combines with the sulphur and is evolved, leaving the chlorine to the antimony. The solution is thus evaporated down till it begins to crystallise in the cold; it is then distilled over from a retort, the pure terchloride being of a buttery consistence, which melts into an oily liquid at 162° Fahrenheit. From having this property it is commonly called "butter of antimony."

From this again may be prepared the oxide, sometimes called "flowers of antimony," by decomposing it with carbonate of soda, when the mixture separates into oxide of antimony and chloride of sodium, with evolution of the carbonic acid. It can also be made by burning the metal itself, when small crystals of the oxide will be found to collect at the top of the receiver.

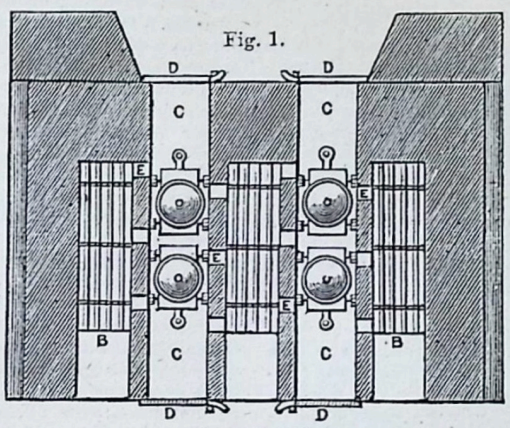


Fig. 1.

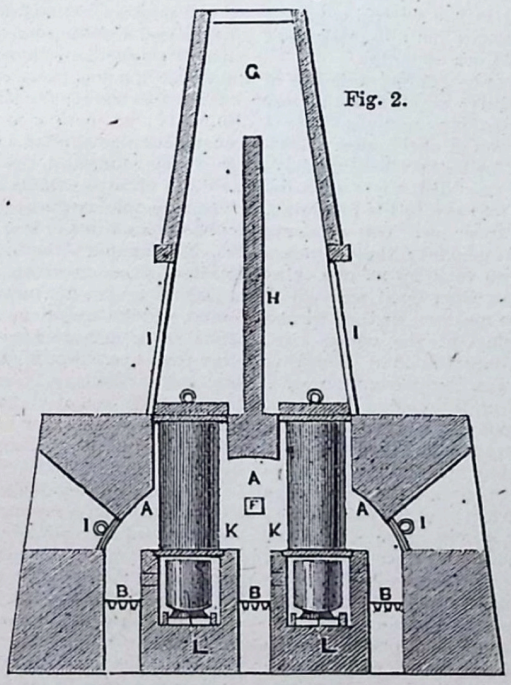


Fig. 2.

BISMUTH.

SUPPLY—REDUCTION—PURIFICATION—PROPERTIES—ALLOYS—PEARL WHITE.

This metal is often met with in small quantities in mining for other ores, but does not occur in sufficient abundance in any mineral district to render it worth pursuing for its own sake. It not unfrequently occurs in the native state, and it is from such that the principal supplies are derived.

As it melts at a remarkably low temperature, 500° Fahrenheit, it is easily separated from the earthy matters or ores of other metals with which it may be associated. All that is necessary is, first, to break up the pieces, so as to remove as much as convenient of the refuse matter, and then place the ore in tubular retorts having a slight inclination towards the orifice. In about ten minutes after the fire has been got up to the right temperature the metal will begin to flow, and in another twenty minutes, during which the ore should be well stirred up, the whole of the metal will have been melted out. As it runs into the receiver it is ladled out and cast into bars.

The metal thus produced will contain a certain amount of impurities, consisting commonly of sulphur or arsenic, and other substances; but these can be in a great measure removed by fusing the bismuth with the addition of some nitrate of potash.

It is a crystalline body of low specific gravity, and very deficient in tenacity, and it has no characteristic to render it of practical utility as a simple metal. It, however, enters with advantage into certain alloys, and some of its salts are useful in medicine.

In speaking of the different kinds of pewters and solders under the heading of "Tin," Article XVII., the employment of bismuth as one of the constituents of these has already been spoken of. They need not, therefore, be recapitulated now. In addition to those uses already named, it should be added, however, that a little bismuth greatly improves the tone of bell-metal.

The most important of its salts is the basic nitrate, commonly known as pearl white. It is formed by the addition of about 24 parts of hot water to 1 of the ternitrate of bismuth, and then evaporating to dryness, the ternitrate being first made by dissolving the metal in nitric acid and crystallising out the salt. If the preparation is to be used in medicine, it is essential to separate from it every trace of arsenic, an article most usually found in combination with it. For this purpose only about one-sixth of the water is added to the ternitrate in the first instance, in which the arseniate of bismuth will not be soluble, so that it can be separated from the rest by filtration.

The alloys which contain bismuth possess a greater specific gravity than the mean of their constituents: thus equal parts of lead and bismuth give, by experiment, 10·538 at a temperature of 14° Centigrade (equal to 57·28 Fahr.), against 10·290, which is the calculated mean.

The metal itself expands on solidifying—contrary to the custom of such bodies—and this has led to its being compared to water, though the analogy is not exact. The expansion

of the bismuth is probably due to the change in the arrangement of its particles by crystallisation, and not to loss of temperature, as up to the very point of solidification the coldest metal is found to be the densest, and to accumulate at the bottom of the liquid—not on the surface.

SANITARY ENGINEERING.—XXVIII.

SUMMARY.

In this our concluding paper upon the subject, we take up no new topics and have no fresh details to record: it is devoted to a simple recapitulation of what has gone before, and is intended to take the position of a summary, or, if we may so term it, *catalogue raisonné* of the entire series. Four leading subjects are embodied in our course: (1) Gas, as representing light; (2) the mechanical processes of artificial warming, as representing heat; (3) the best means of obtaining a supply of fresh air, under the head of "Ventilation;" and (4) Drainage and Water-supply, as connected therewith—the last, not least division of the subject, as representing what the general public consider as sanitary engineering, strictly so regarded. The order in which we have treated these various matters was decided, to a certain extent, by their relative importance. Our object in this publication is supposed to be purely technical, that is, to explain the way in which practical matters are carried out. Theory takes no place in the arena—practice and pure practice, what has been done and is being done, and how, that is the subject-matter of our communications. We may confess that the idea of commencing the series by some papers upon "Gas" was suggested by a passage in the first and best book in the world—"Let there be light." Without light, no work can be done; our days in this dull climate are short in the winter months; and therefore the best scientific appliances for obtaining light at the most moderate cost first occupied our attention.

Having light sufficient for our work, we bethought ourselves of the next requisite throughout all the winter months of the year in large factories, warehouses, printing-offices, and elsewhere—*warmth;* and therefore the second portion of our Sanitary Engineering was devoted to the mechanical details of artificial methods of warming; but with light and heat provided, there then occurred the third point, accessory, as we may say, to the foregoing, and that was the means of supplying fresh air. Gas products are unwholesome, and dry burnt air is noxious; these vapours have to be got rid of, and we therefore took up as our third heading, "Ventilation." Having given from good authorities the best data at our command on these matters, we then turned to the final and most important subject of the whole—viz., Drainage and Water-supply, not less important, but occupying for other reasons a subordinate position in the present series.

Thus generalising the main objects of the course before us, we now proceed to give a short abstract of the various papers, which, with this last contribution, have reached the number of twenty-eight. In our first paper we took up the mode of the manufacture of gas by public companies, giving the particulars of material and method, and as much detail of construction, etc., as the space at our command would admit. The subject of No. II. was gas-burners, the tools, as it were, or media through which this supply is consumed in its daily use: the difference of simple jets, bats'-wings, fish-tails and argands, the technical names for the ordinary kinds of burners, are there explained.

In paper No. III. we dealt with the method of measuring the amount of actual light obtained from these burners, and the way in which the light given by one burner might be compared with that given by another, varying sizes and capacities fairly calculated, and, as well as we could, explained the principles upon which "photometry," or the measurement of light, was carried out. The text of the paper might be "The Quality of Gas."

In No. IV. we described private gas-works, and showed how anybody, if his requirements were sufficiently extensive, could make his own gas, and save money thereby. For the detail of the appliances we must, of course, refer our readers to the paper in question.

No. V. deals with a question not of economy but of "power." A mass of central concentrated light at a high level for public rooms and buildings, lecture-rooms, manufactories, etc., combined, at the same time, with an efficient system of ventilation, is always most desirable, and we showed how those ends can be attained by the "sun-burner."

No. VI. again takes an economical view: it explains the methods by which gas is measured, and shows how a man can arrive at an accurate result as to the quantity of gas burnt in his house or factory; and while we explained the difference in the construction, we carefully abstained from expressing an opinion in favour of either "wet" or "dry" gas meters. This paper might be headed "The Quantity of Gas as distinguished from its Quality."

No. VII. explains the method of cooking by "gas," and the fittings required. A kettle may thus be boiled, or, to take the maximum view, a dinner for 1,000 people may be cooked more cheaply than by the ordinary method.

In No. VIII., our last paper on the gas question, we showed how gas was utilised for heating baths, lighting theatres at the foot-lights, generating steam-power, and various other commercial purposes.

Having thus summarised our first head "Gas," we now come to our second subject, "Warming." No. IX. of the series shows how, by circulation through a series of pipes, water *under* the boiling-point, 212°, may be utilised to diffuse heat throughout a large area at a moderate cost.

No. X. deals with a kindred topic, but with the water heated above the boiling-point, the "high-pressure" system as it is called, with strong wrought-iron tubes, and a pressure of anything under 600°.

No. XI., on heating by hot air and steam, briefly explains the construction of some of the hot-air stoves, in such extensive use on the Continent, and gives some data as to the utilisation of waste steam in factories, etc., for general warming purposes.

We thus dismiss the details of Warming, and come to those of Ventilation. In No. XII. we give, with illustrations, some of the most recent and handy inventions for the ventilation of rooms and dwelling-houses. No. XIII. treats of the ventilation of public buildings, a much wider theme, and subject to more varying conditions; the general principles to be observed we have, however, explained as clearly as we could. And in No. XIV. we give examples of some successful ventilating construction as applied to hospitals, when, in addition to heated air, respiration, and the products of combustion, air charged with the vitiated effluvia of disease has to be dealt with.

This completes the second and third sections of our subject, and brings us to the last heading—Drainage and Water-supply. No. XV. supplies the details for supply of water, with particulars of construction and cost, to towns and villages upon a limited scale—*i.e.*, when the supply is comparatively small—and will be useful as a reference where an isolated country mansion or manufactory is situated at a distance from ordinary facilities. No. XVI. takes a cursory view of the present position of the supply of the metropolis and large provincial towns, with some slight allusion to water as a mechanical *motive* power, and also to water-measurement, which is yet in its infancy as a system, but which, we hope, will be largely developed in its application at no distant day.

Proceeding onwards in our general view, No. XVII. explains the method of the manufacture of the pipes through which water is laid on, and gives some economical statistics, comparing lead with iron as the material of their manufacture, which, we venture to think, will be found worthy of attention. No. XVIII. goes one step further, and deals with the construction of cisterns, the appliances at command for the *economising* of water when the supply is likely to be restricted, and enters into a subject as yet little before the public, the desirability—we ought perhaps to say the necessity—of a provision for the ventilation of a system of pipes for water-supply or otherwise.

The water being therefore supposed to be laid on, and the cistern provided, we next come to the heading, unsavoury in its nature, but none the less important in fact—perhaps we may call it the key-note of Sanitary Engineering proper—that of closets and traps. In a long and fully illustrated paper, we have given the detail of the best modern inventions for these necessary conveniences, and explained the principle of their operation.

Paper No. XX. is devoted to an explanation of a system recently introduced, but well worthy of attention—Moule's earth-closet system. Here water-supply is dispensed with, and an efficient sanitary closet arrangement is provided, dry earth being the only requisite. For details, we refer to the paper.

In No. XXI., still proceeding in our practical sequence, house drainage is the subject. With the manufacture of the

pipes we do not here deal—that will be found in other series of THE TECHNICAL EDUCATOR: we explain only the rules for their ordinary laying, and the varying forms of construction at command. The ventilation of in-door pipes having been already explained, in No. XXII. we go into the question of the ventilation of house-drains, and give illustrations of some new matters in the way of air-escapes and disinfecting apparatus, which will, we doubt not, in future be extensively adopted, though not widely known at the present time; and from the house-drains the thread of our investigations naturally conducts us to the sewers. In No. XXIII. we give what we may call working drawings of the sewers in the metropolitan districts, and also deal with the question of subways, illustrating what we have to say by examples which have been carried out, and are now satisfactorily at work. The sewers being built, the question of their ventilation is an important one; and in No. XXIV. we give the best and most recent data upon the subject.

The disinfection of sewage and its application as a valuable commercial article are now receiving much attention. With the latter portion of the subject we do not here deal, but in No. XXV. we give particulars of what has been the result of extensive experiments in London upon the disinfection of sewage gases, and also some description of works now in operation for disinfecting sewage in a solid form.

The practical side of the question being thus disposed of, in paper No. XXVII. we give the actual result of the adoption of a comparatively enlightened system of hygiene in some of our large provincial towns, extracted from reliable Government authorities, showing clearly that the adoption of well-considered sanitary precautions has its immediate and marked result in a largely decreased *death-rate*, wherever these matters are properly taken up. The object and end of all sanitary engineering is to improve the health of the population, and the data given in the last paper show clearly that this is no chimerical idea, but that the saving of life—for it comes to that—is represented by large per-centages. For figures, we refer our readers to the details.

By means of these last figures we bring the matter, as it were, to book, and eliminate tangible results: the intermediate stages of improvements; the diminution of danger from cholera; the control—we can use no other word—of typhoid fever; and the improved physique, resulting from a better state of general health, especially among the lower classes, are elements which, though they cannot be exactly calculated and stated in figures, are very important objects of attention. If the technical information contained in this series of papers facilitates in any way the adoption of any of these, which may fairly be called the requirements of the day, the object of their publication in THE TECHNICAL EDUCATOR will be well and thoroughly attained.

SOLDIERING.—VI.

BY A STAFF OFFICER.

EQUIPMENT (*continued*): IMMEDIATE NECESSARIES.

IT will not be advisable to enter very fully into the subject of these, for their character in war differs entirely from time to time, according to the circumstances of each special case. The general conditions are easily explained.

The differences which the nature of the three chief services impose must be taken into account. Care must be taken that no more is given to the infantry soldier than he can carry during long marches, and that the weight is distributed over his body in whatever way may be most conducive to ease and comfort in marching.

Sir Charles Napier was said, during one of the campaigns in India, to have reduced even the officers' equipment to a piece of soap and a tooth-brush; and of course there are times, as in the Abyssinian campaign, when nothing whatever which interferes with the rapidity of advance can be allowed. All such extreme restrictions are, however, sure to be borne by an army with greater alacrity if they are not imposed unnecessarily. Moreover, the distress occasioned by an entire absence of means of comfort tends itself to produce inefficiency. The great object, therefore, to be obtained in all arrangements for the supply of the men's needs is, as far as possible, to develop a system of rapidly supplying any deficiencies in what they carry, and to restrict what they do carry, as far as possible, to those things only which could not certainly be supplied to them before they will need them. The total weight which, in ordinary service, each of our soldiers is intended, with the new equipment, to carry is, including the clothes he wears, a little less than fifty-two pounds.

Under any circumstances, a considerable number of rounds of ammunition in addition to the carbine is indispensable for the infantry soldier. In the British army we carry seventy rounds per man.

Some means of cooking food and carrying water is indispensable. Our men carry a mess-tin and a water-bottle. In addition, certain articles of clothing are almost essential to health, and altogether to comfort.

A sufficient supply of ammunition must be on each man's person. Our established allowance is seventy rounds per man. It must, however, be noted that the actual duty on which men are engaged in each particular case must decide the proportion of ammunition to other stores which it is advisable that each man should carry. Where an action is likely to be fought by any particular corps, the men of that corps must have their full allowance of ammunition. As usually it is not easy to provide adequate supplies of food during the period of an action, something to eat and drink is indispensable also. On the other hand, where troops are likely to be engaged in long marches without fighting, good boots and clothing become all important. During the Franco-Prussian war (1870), whole regiments were put out of fighting condition by the contractors having sold boots with brown paper soles.

In the case of cavalry, the man's capacity for carrying weight has no longer to be attended to, but that of the horse has. Moreover, food, means of grooming, and some clothing have to be provided for the horse as well as for the man. On the whole, however, the surplus weight which cavalry can carry is not very great. The artillery alone are tolerably independent as regards the necessity for providing for the immediate personal needs of men and horses. The weight of their carriages is so great, that it makes little difference whether a few extra pounds are added or not. As a rule, therefore, their gunners do not carry the stores hitherto referred to, but these are partly carried on the horses and partly on the guns.

TRAINING.

It has always been hitherto the habit to divide the subject of a soldier's "training" into two parts—"drill" and "discipline." I have pursued that division in the syllabus of the present course for this reason. We are at this moment, in military matters, in a state of transition. The nature of actual fighting has changed in most important respects. But the preparation for a soldier ought to be primarily for fighting. When, then, the nature of the fighting changes, the nature of his preparation for it inevitably changes at the same time. There, can therefore, be no question that we are now in presence of an absolute necessity for so modifying the training of our army as to meet new facts. Nevertheless, there is no body to which sudden and violent change is so detrimental as it is to an army. Hence it is before all things important that any changes of mere form which we introduce should be carefully thought out. One desires in all terms and expressions to keep as closely to the past as possible, while gradually infusing into them the new spirit which is required.

In order to understand, however, how far "training" can now properly be said to be a term precisely co-extensive with the two minor headings of drill and discipline, it is necessary to make clear first what has usually hitherto been understood by "drill." It by no means follows that the word may not have a new force given to it, which will enable it fully to include what is required.

It is said that the word is derived from an old French term signifying "soldier." It would thus be almost the equivalent of the term which I have taken as the title of these papers—"Soldiering." If that was its meaning at first, it has certainly been very much restricted since then. Practically, "drill" has included only the teaching of a soldier how personally to use his weapon; how to use it so as not to interfere with the men beside him; how to work with these by means of some definite formal movements; and, in addition, the instruction necessary to enable those who were to convey to him the orders by

which he was to act, to issue them as they were required. Let us consider first the means by which the army has been brought, under the orders of its commander, into situations from which it could act upon the enemy. It will be remembered that in speaking of the use of weapons we had to take account of the division of the army into the three great arms of the service—infantry, cavalry, and artillery—due to the nature of weapons, and to the extent and manner in which we employ the services of the horse. For each of these arms or branches of the service a separate drill is necessary.

To take first the infantry. Here our drill must be adapted to enable the men to bring into play, at different times, two different kinds of weapon, the fire-arm and the bayonet. It will have been noted that in describing the manner in which these weapons were severally used in the Peninsula, the bayonet was always the finally deciding arm. The fire was only a means of creating a certain moral effect preparatory to the bayonet charge, which though seldom carried home, was the active cause of the breaking up of the enemy's power, and of his final flight. Now, from the simplest considerations, it is abundantly clear that if men are standing one behind another, row behind row, to a great depth, they will not be able to fire so effectively as if they stand in a single or double row side by side. With two rows or ranks, each rank can, by a little adjustment of the weapons, fire well enough. Even with four ranks, if the front two kneel down, fire is easy for all four at the same time. But you cannot increase the number of ranks beyond that, and yet having your men close side by side, and close one behind the other, continue to let every man fire, for those in the middle will fire into those outside them. Hence, when actually engaged in firing at the enemy, in the old days, troops were, if possible, formed side by side of one another in not more than four ranks. This formation a few ranks deep we call a "formation in line." The formation with a succession of ranks one behind another we call a "column." With us the formation in line is in two ranks. The Prussians employ, till they come on to the battle-field, three ranks, as we also did at one time.

The effect of forming a succession of ranks, one behind another, is clearly that the same number of men will occupy less space in front in proportion as we increase the number of ranks which stand one behind another. A thousand men in line in two ranks occupy from A to B (Fig. 1) 1,000 feet. The same number of men in ten ranks occupy from C to D (Fig. 2) only 200 feet. The most cursory glance at the two figures shows at once how much more convenient for the purposes of rapid movement the formation C D E is. In the first place, we may be often able to find ground which will allow men to pass on a front of 200 feet, such as C D, but will not at all admit of a body in a formation so extended as A B passing at all. Secondly, it requires very much more elaborate training to teach men how to keep their places whilst they are moving forward in line, A B, than to teach them to do so whilst they are in column, C D E; for the very slightest displacement of any man in the long line A B throws out others, and as this process constantly tends to increase as the movement proceeds, the line becomes more and more irregular till, without the most extreme perfection in drill, in moving over ground presenting the slightest irregularity, all order is lost. Obviously this evil multiplies in proportion to the length of a line. Hence for an army it may practically be said that for purposes of movement the only formation is a column; for purposes of firing the only close formation is a line. By "close formation," as to infantry, is meant any arrangement of the troops in which the men stand in each rank as close together shoulder to shoulder as the free use of their weapons will allow them to stand. At present with us each man is allowed 24 inches, so that any given number of men in two ranks occupy as many feet of front as there are men in the two ranks. The rear rank stands back from the front rank one pace of 30 inches, measured from the heels of the front rank to the heels of the rear rank. In column the two ranks which form the line stand at the same distance apart as in line, whatever the nature of the column may be; but the distance of each two from the next two depends on circumstances now to be considered.

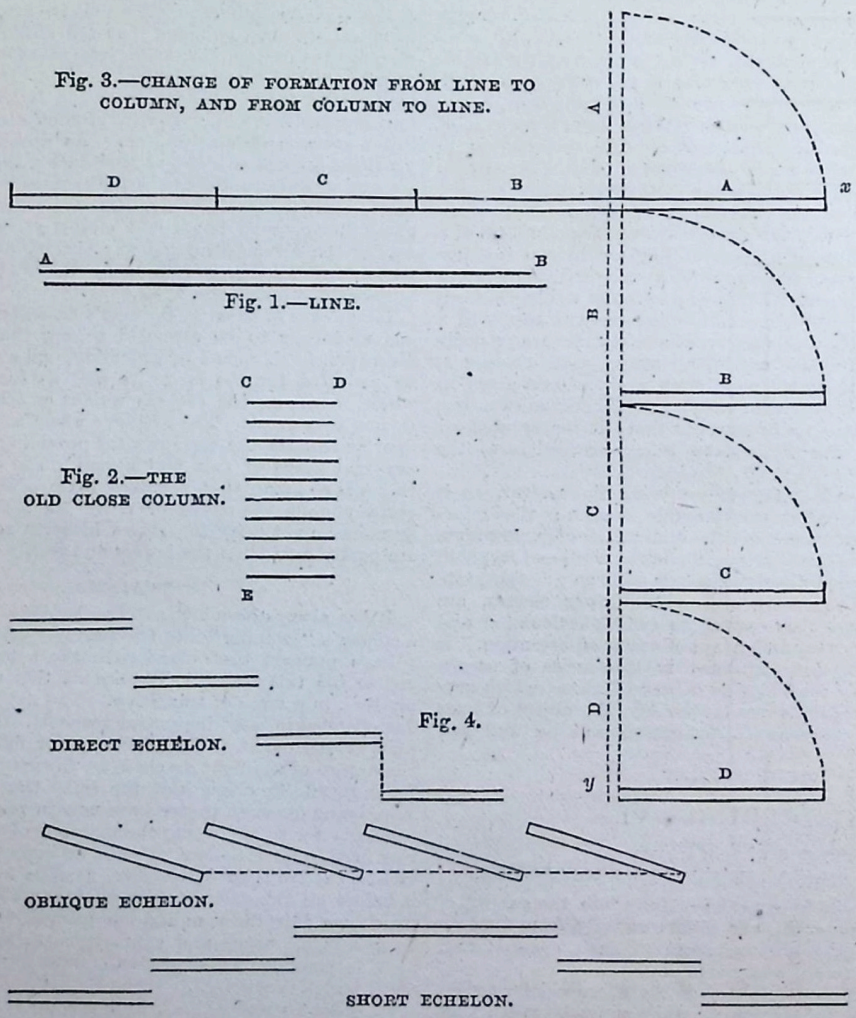


Fig. 3.—CHANGE OF FORMATION FROM LINE TO COLUMN, AND FROM COLUMN TO LINE.

Fig. 1.—LINE.

Fig. 2.—THE OLD CLOSE COLUMN.

Fig. 4.

Since for purposes of movement we require columns—for purposes of firing, lines—it is clear that we must be readily able to change formation from line to column and from column to line. Now the kind of column which will most readily enable us to form line is one of this kind.

Suppose a certain number of men drawn up in two ranks in line, and divided into four parts, A, B, C, D, as in Fig. 3.

Now let B, C, D be arranged behind A in this way, where the order is such, that from the front rank of A to the front rank of B the distance is exactly equal to the front occupied by B. From the front rank of B to that of C the distance is exactly equal to the "front" of C, and so on. If the column thus formed marches so as always to keep these distances, it will be able to form line again at once to the left of the column in the old order,

by letting each part, A, B, C, D, "wheel on its own ground," as it is called; that is to say, that if the left of each part, A, B, C, D, remain where it is, merely slowly turning to its left, while the right sweeps round along the dotted line, the whole will again be in line, and A on the right of the line as before, and D on the left. The column $x\ y$, which possesses this property and is arranged in this way, is called an "open column," or for brevity it is described as simply "column," all other formations in column having special names assigned to them. It is clear that a similar column might have been formed by placing the several parts of the line in the opposite order behind D instead of behind A; then D would have been in front, C next, and so on, A being in rear. The column with A in front we call a column "right in front," the column with D in front we call a column "left in front." It will be seen that if instead of letting the several parts each wheel to the left in the manner shown in the figure, where A is in front, we had allowed them each to wheel to the right, we should have no longer had D on the left of the line, but on the right of it. So also A would no longer have been on the right, but on the left. The line thus formed would have been said to be "inverted." We always number the parts of our line from right to left, and if we allow the right to become the left, such practical inconveniences ensue from the inversion that we are obliged to change the order and number them off again from the right. Hence though we do, where necessity requires it, wheel to the right instead of to the left when the right is in front, it is not at all convenient to do so if it can be helped. Similarly with a column left in front (*i.e.* in the order D, C, B, A), we can re-form line in the old order if each of the several parts wheel to the right. As long as we are on the march there is no inconvenience in having right or left in front. Therefore, by always placing in front the right or the left, according as we intend afterwards to form our line to the left or the right of the column, we can usually arrange to have this formation very adaptable to certain contingencies.

It will, however, be observed that the depth is very great, being in fact equal to the whole front occupied by B, C, and D, or, as we may otherwise express it, by the length of the whole original line less the front of the leading part. If we want to form the line to the front instead of facing the right or left of the column, D has a long way to go in order to move into its place on the left. Moreover, in order that each body B, C, D may move into its place in line, specific orders have to be arranged, which may be given to B, C, D severally, in order that they may move in the quickest manner, and without interfering with one another.

A general order as to the nature of the movement to be executed by the whole body may be given by one commander; but each one of the several fractions will require to receive specific directions from a man who accompanies it, and who, at the moment when it requires to change its direction, will give it the required order. For such a drill as this, then, it will be suffi-

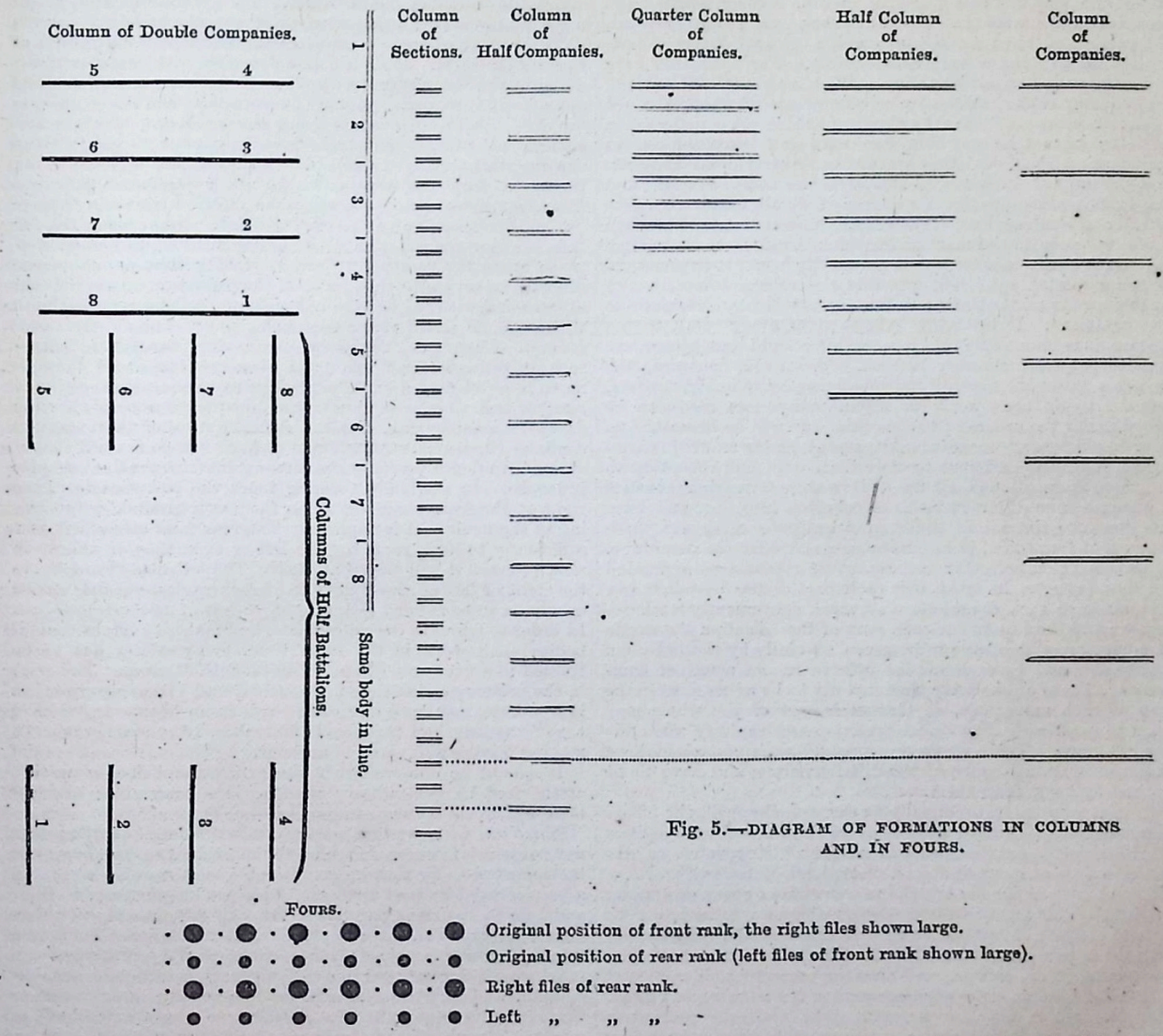


Fig. 5.—DIAGRAM OF FORMATIONS IN COLUMNS AND IN FOURS.

cient if we form together as one whole bodies large enough, when in line or when broken from that into column, to be able to hear the orders of one man. The body thus formed will require to be broken up into as many parts as convenience may suggest. The size of the larger body is, in fact, determined by the convenient limits of the human voice. The body whose size has thus been fixed we call a "battalion." In all armies this has been reckoned much alike hitherto. Where a difference in the size of battalions has existed, it has been because the troops of the larger battalion were, when in line, formed in three ranks instead of two. No army has attempted to place in the field, under one man's direct personal orders, a body whose front occupied in line more than about 800 feet. On the other hand, the number of "companies" into which the battalion has been broken up has varied very considerably. The Prussians have four companies in their battalion. We have eight. The size of the company is fixed rather by considerations of what is called "interior economy" than by those of drill. A company is, in fact, the largest body which one man can conveniently, in accordance with the existing system, look after in all respects. It is the duty of a captain to attend to the order, comfort, and well-being of his men, with a degree of detail which no officer superior to him requires. The officer commanding the battalion issues orders as to the manner in which detail is to be carried on; but it is the captain who is personally bound to superintend its being carried out. The possible size of the company very much depends on the nature of the duties which are assigned to the subalterns. If the latter have to refer every detail to the captain, it is impossible that the captain should look after more than a very small number of men. If, on the contrary, the captain's duty is to see that his subalterns carry out his orders, but not to do their work for them, many more men can be placed under the orders of the captain. It will be necessary to recur to this question again. At present, so far as drill is concerned, it will be sufficient to note that, with one exception to be presently mentioned, all the drill in close formations consists in changes from different forms of cohesion into line, and from line back to these. In order practically to carry out these changes of formation, it has been necessary first to determine, by the careful experiment and report of committees appointed for that purpose, in what way each part of the battalion can best move so that the whole may most conveniently work together; and then to fix for each part of the battalion the words of command, which have to be given severally by the battalion commander and by each of the officers in command of companies. These orders have then strictly to be adhered to in the case of each movement, so that each part of the whole may learn to work with mechanical precision and rapidity when the word is given. These words of command are, in fact, laid down in the several drill-books of the different arms, and have to be learned by heart from them.

In order, however, practically to carry on the drill, the officer who conducts it has to acquire a good many other qualities besides those of mere accuracy of memory. He requires to give out his words of command in a clear, loud, unhesitating voice. He must keep under his eye the movements of every one under his orders. He must instantly detect where anything has gone wrong, see who it is that has made the mistake, immediately stop the movement of the whole, and have the error corrected. In training young troops, and even in perfecting older ones, if this is not done an error once committed tends to repeat itself, and the drill is mischievous, not useful. To be prompt in seizing upon the least blunder at the moment when the officer is himself watching to give the next necessary word of command exactly at the right moment, neither too slowly nor too hurriedly, needs much practice. It constitutes the difference between one who is known as a "good drill" and a bad one. It by no means ever comprised all the qualities which went to make up a "good officer;" but a good many of them are still practically involved in it. I propose here to name only the different formations. The words of command adopted are quite irrelevant to the purpose of these papers. An understanding of what the different forms are, and their purpose, is, on the contrary, essential to all that is intended to be explained in them.

Suppose that the body formed in line is now considered as a battalion, and that we suppose it divided into eight companies. I do not think it will be necessary for our purpose to speak in detail of the positions taken up by the officers during movement. It will be sufficient to say that the usual place for the captain is in rear of the centre of his company, but that he is not restricted to any particular spot, his duty being generally to look after the movement of his men. There are two "guides" for each company, properly the two subalterns of it, and there are two "markers," usually sergeants. The former see to the guiding and "dressing," or straightening of the company from the right or left, as the case may be. The one whose flank is not that from which the guiding is given is in rear of the company. The chief duty of the markers is to mark the points on which the flank of their company is to move. In line the colours are in the middle of the battalion. The diagram (Fig. 5) shows more clearly than a description what the characteristics of the different columns are. I have already described the nature of that on the right. It is a column formed with each company distant from the one in front of it its own length in line. The one next to it is also a column of companies; but the companies are half the distance apart from one another. The quarter-column is the formation which, from its greater compactness, is the one most employed when large bodies of troops are working together. In it the companies are not a quarter of their own distance apart—as might perhaps be inferred from the name—but six paces, or five yards. It is, in fact, more convenient for this, the closest formation we adopt, to fix definitely what distance apart the companies shall be rather than to allow the distance to vary with the length of the company. It is obvious at once that with neither the half-column or the quarter-column will a simple wheel of the companies be possible on their own ground. They would come up against one another. Therefore, in order to form line from quarter-column, we have to move in a different way. This brings us to the consideration of another and simpler kind of column, employed not only for the detail of manœuvring, but the ordinary form of movement in confined situations. A "column of fours" is so formed that it occupies in depth precisely the same extent that the line occupies in length. In originally forming fours the odd files from the right of the front rank remain on their own ground, only turning to the flank that is required. The rear rank steps back just sufficiently to leave room for the left or even files of the front rank between it and the front rank. The left files then form to the right or left of the right files of each rank according as the column is to be formed to the right or left of the original line. In order to regulate the movements, and make it certain that all bodies shall work in the same time, every soldier has to be trained to a fixed rate of march and length of pace. The pace in the ordinary quick time is 30 inches, and 116 paces are taken in a minute, making 3 miles 520 yards in an hour. In "double time" the length of the pace is 33 inches, 165 paces per minute, making 5 miles 275 yards in an hour.

It should be observed that the expression "double quick," often used by non-military writers, is a long since obsolete term which has no place in our drill-books.

There are various other matters, into the detail of which it is not necessary to enter, in which the individual soldier has to be instructed in order that he may be able to move with others in a precisely determined manner. Such are his turnings to right and left, to the right and left about, half left, half right, three-quarters left about, three-quarters right about, etc. Supposing this instruction acquired, it is obvious that by properly regulated words of command line can be formed from the quarter-column, and quarter-column from line readily in any manner that may be required. In addition to the three kinds of column already noted (column, half-column, and quarter-column), we have what is called column of double companies, and column of half-battalions. In the column of double companies the two centre companies are in front, the two nearest to the centre follow next at a distance of a length of a company from them, the others following in a similar order, as shown in the figure. In the column of half-battalions the column, instead of being practically single but of double-company front, is broken up into two columns formed on the left company of each half-battalion, as shown in the figure. The column of double companies is very convenient when it is intended to re-form line again to the front, when the ground admits of so wide a front for movement as that of two companies, and it is not necessary to shorten the column considerably. It should be observed, however, that this formation is only adapted for use in cases in which, when it is intended to form line, it will probably be con-

venient to extend the front on both flanks at the same time. In the columns of half-battalions the depth is the same as that in the column of double companies, but a less front is exposed to fire at any one spot, a less width is required for the movements of either column: to bring the line into its original order on re-forming for action it is necessary to form on the right of the leading company of each column.

So far we have considered only, except in the special case of the formation of fours, columns formed of some combination of companies. Other columns are, however, used, in which the smaller subdivisions of a company—namely, half-companies and sections—are the separate bodies which together form the column. A half-company is, as its name implies, the half of a company; a section is the fourth of a company, or half of a half-company. At present we only employ columns of half-companies and columns of sections for purposes of marching, the object of their use, in fact, being to enable us to have the largest front which the ground will admit of, in order, as far as possible, to reduce the length of the columns. For use in the manœuvres of battalions, and therefore of larger bodies, we do not employ these latter, but only the columns which have been already referred to. We have, however, another very valuable method of movement in close formation—viz., "echelon" (Fig. 4.) In this the several parts of the line are broken up, so that each moves, to some extent, independently. In the case of "direct echelon" as much fire is available to the front as in line. Both direct and oblique echelon have a property the full value of which can hardly be appreciated without going further into certain questions of tactics than would here be possible, but the simple advantage of which is obvious. It is clear that when a body of men are so arranged side by side as to be able to direct all their fire to the front, they cannot fire to their direct right or left, each man being in the others' way. The line must wheel, or some change of formation must be made, in order to bring fire in this direction. If the line is of great length, a change of front or of position is a very elaborate and difficult operation, especially if, as is usually the case, any part of the line has to be thrown back.

GREAT MANUFACTURES OF LITTLE THINGS.—XI.

SCREWS (*continued from page* 118).

BY CHARLES HIBBS.

The introduction of the American machinery effected a complete revolution in the screw trade, not the least of the changes being the complete extinction of the smaller manufacturers, and the almost entire absorption of the trade by one large and enterprising firm, that of Nettlefold and Chamberlain. Very great improvements were made in the machines, and the original American plant has been superseded by one of English manufacture. The following extract from an article on the wood screw manufacture, written by Mr. Joseph Chamberlain, member of the eminent firm just mentioned, for the volume on "Birmingham, and the Midland Hardware District," will convey an idea of the perfection to which the processes have been carried:—"The wire having been headed by a machine, . . . the forged blanks are carried to the turning and nicking machine, and are placed in a hopper above the machine, from which they are taken one by one by a mechanical arrangement, which places them in the machine where the heads are first turned, then nicked, and lastly re-turned to remove the burr left by the nicking saw. The blank thus nicked and turned is then delivered by the machine into a bucket placed to receive it. All these operations are performed in one complete revolution of the machine, and the nicked blanks are thus produced in a single operation instead of requiring three, as they would have done in the old-fashioned machinery. They are next carried to the worming machine, and placed in a hopper similar to that of the turning machine. Thence they are fed into the machine, and a cutter is now passed along the blank often enough to produce a thread of the required depth, at the same time forming a point at the end; after which the screw is taken out of the machine, and, as in the case of the turning process, put into a bucket below it. The machines being self-acting, one woman can attend to many of them, whilst on the old principle one attendant was required to every machine. The work is also much lighter, as it is only necessary to supply the hoppers with blanks and to change the cutters from time to time as they become worn."

Among the advantages claimed by the same writer from the adoption of the new method are these:—"Healthier workplaces, regularity of hours, economy of labour, increased demand, lower prices, and at the same time higher wages; in fact, the salaries of foremen in many manufactories now are larger than the average profits of small manufacturers formerly." With regard to the item of increased demand, a sufficient confirmation is afforded by the fact that on the premises of the firm alluded to, comprising three large mills worked by steam-power, the make is probably not less, upon an average, than 130,000 gross per week, more by 30 per cent. than the total make before the introduction of the machinery. More than 5,000 tons of wire are consumed annually, and the cuttings from the threads, or "soife," accumulate at the rate of four tons per day. The screws turned out from the machines, though some of them are only three-eighths of an inch in length—and small sizes form the bulk of the production—would, if placed end to end, reach from London to Liverpool in less than three days.

The manufacture of patent nuts and bolts has become an important branch of industry during the last few years. At the once famous London works an immense number of these articles are weekly produced, chiefly for railway work, fastenings for rails, and for carriage and wagon building, as also for shipbuilding and engineering work generally. By the patent machinery in use fifty to eighty nuts can be produced per minute, varying from a quarter of an inch to three inches in diameter, and of the most perfect form and structure. So exact are the results that all the parts produced of a given size are interchangeable, no matter at what date they may have been turned out. From 500 to 1,000 tons per week are produced at these works alone, an additional exemplification, if any were wanting, of the multiform application of the screw, and of its great importance as an article of commerce.

To enter on an exposition of the value of the screw as a mechanical power is unnecessary, as this has been already done in the series of papers on "Applied Mechanics," while the methods of constructing a helix and projecting a V-threaded screw have been detailed in the lessons on "Projection." Its advantages also are self-evident, and not the least conspicuous of these is its superiority over the ordinary nail as a means of attaching locks, bolts, brackets, and metal fittings of all kinds to wood, and even for attaching one piece of wood to another, if the removal of the piece attached may become a matter of necessity at any time. And here we may be permitted to enter a protest against the bad habit which most carpenters and joiners unfortunately contract, of putting screws into the mouth, or holding them between the lips and teeth, to keep them in a handy position for use as soon as the holes are bored which are intended for their reception. The consequence of doing this is that the screw more readily contracts rust, and its removal often becomes a matter of extreme difficulty. To ensure easy withdrawal at any time, the end of a screw should be dipped in grease, or smeared with it, instead of being put into the mouth.

Some years ago, an attempt was made to introduce a new kind of nail fashioned somewhat on the principle of the screw, that is to say, the nail, instead of being perfectly straight from head to point, was twisted so as to turn once or twice in its length, the edges of the sides forming a thread similar to the thread of the screw, but, of course, being extremely shallow. The form may be readily seen by tapping a nail at top and bottom with pincers, and turning them in contrary directions. The nail, however, contrary to expectation, did not find favour among those who use nails, and its manufacture, we believe, was soon abandoned. In driving the nail into wood, the screw-like shape that had been given to it caused it to turn once or twice, according to the extent of the twist that had been given to the nail. In extracting an ordinary nail with the pincers it is manifest that it will be so bent as to render it useless, unless it be straightened again, which involves more care and trouble than the nail is worth. In drawing the screw-shaped nail, however, it was merely necessary, after gripping the head, to pull the pincers, twisting them round at the same time, when the nail would be extracted in the same condition in which it was before it was driven into the wood, and without breaking the edges of the hole into which it had been driven.

TECHNICAL DRAWING.—LXXXVII.

DRAWING FOR METAL-PLATE WORKERS.

FIG. 632.—The subject of this study is a section of brass sash-bar of a very simple form, given as an application of geometrical drawing.

Draw the perpendicular A and the horizontal B C.

Next draw the horizontals D E and F G, and terminate them by the perpendiculars D F and E G.

Draw the horizontal line H I, setting off H I at equal distances from the central perpendicular. From the centre draw the outer circle meeting the horizontal in H, I.

From F and H and G and I, with radius F J, describe arcs cutting each other in J and K.

From J and K draw the arcs H F and I G, and from A set off on B C the distances L and M. Draw D L and E M.

Draw the horizontal N O, and the arcs L N and O M, which will complete the external form.

The inner line is parallel to the outer one, and is drawn in the same manner.

The section lines are of course drawn by the aid of the set-square of 45°.

Fig. 633.—This is another exercise of accurate drawing similar in character to the last.

Set out the horizontal lines as in the previous figure, and find the points A, B, C, D.

Draw A B and C D, and bisect these lines in E and F.

From A and E describe arcs cutting each other in G, and from E and B describe arcs cutting each other in H.

From H describe the arc E B, and from G describe the arc E A, carefully observing that these arcs must meet with the utmost accuracy without overlapping. This practice has been shown in the construction of the Cyma Recta moulding in "Drawing for Stonemasons."

We now proceed to the application of some of the principles of projection and development, as specially applied to the present branch of industry; assuming, as in the case of "Practical Geometry," that the student has made himself thoroughly acquainted with the general principles of the subject from the lessons already given.

Fig. 634.—A B C D is the plan of a cube, and E F H G is the elevation, which in the present position of the cube is the same shape as the plan. For it will be evident that since the cube consists entirely of squares at right angles to each other, the piece of ground the object stands upon must be a square, and also that the side standing on A B is parallel to the vertical plane, and hence its elevation is the square E F H G.

Fig. 635.—In this study the object has been rotated so that

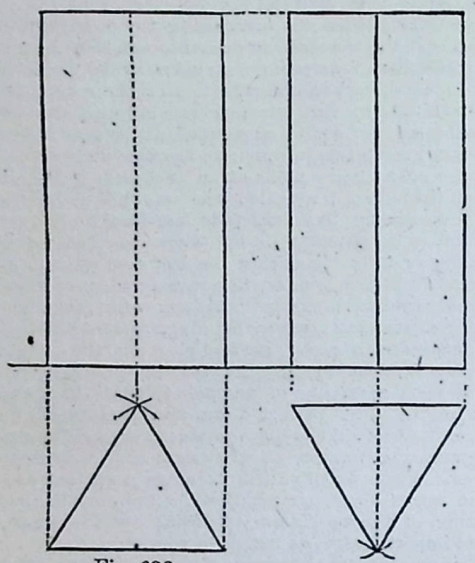


Fig. 636. Fig. 637.

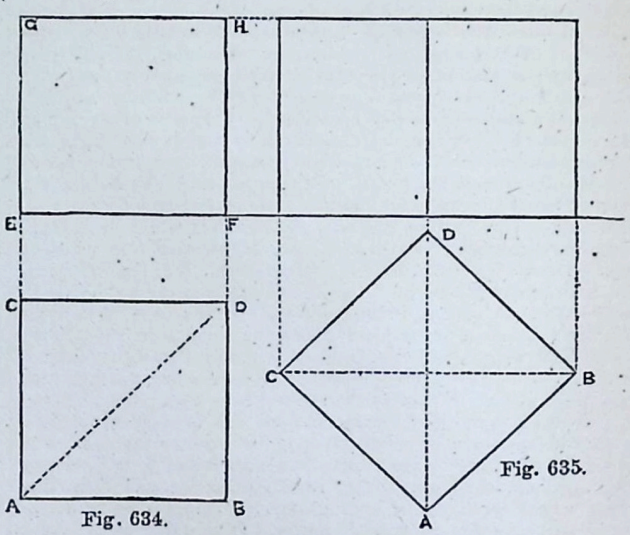


Fig. 634. Fig. 635.

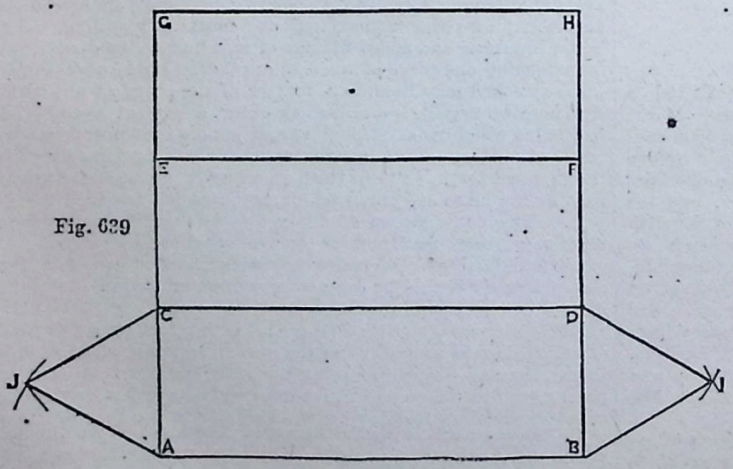


Fig. 633

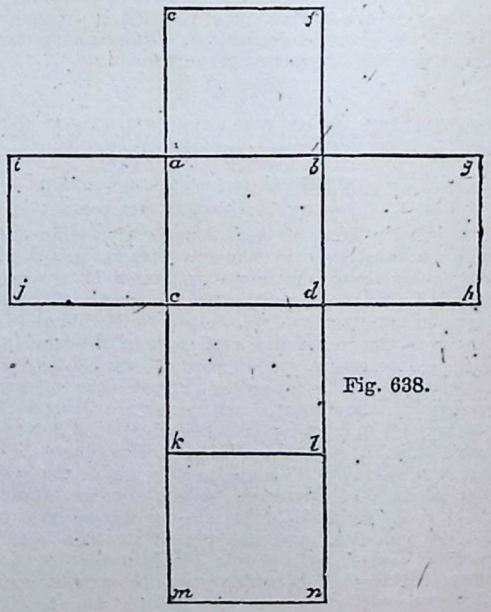


Fig. 638.

one angle, A, faces the spectator, and thus in the elevation two sides are visible, neither of them, however, appearing of its real width, whilst the height remains unchanged.

Fig. 636 is the plan of a triangular prism, the one face of which is turned towards the spectator, and thus, as it is parallel to the vertical plane, the elevation is simply a rectangle.

Fig. 637 shows the same prism when turned round, so that the face parallel to the vertical plane is at the back, and one edge facing the spectator; the elevation is thus two rectangles, the boundary line, however, being the outline of the rectangle, which is parallel to the vertical plane.

It has already been said that an object apparently solid is not

Fig. 632.

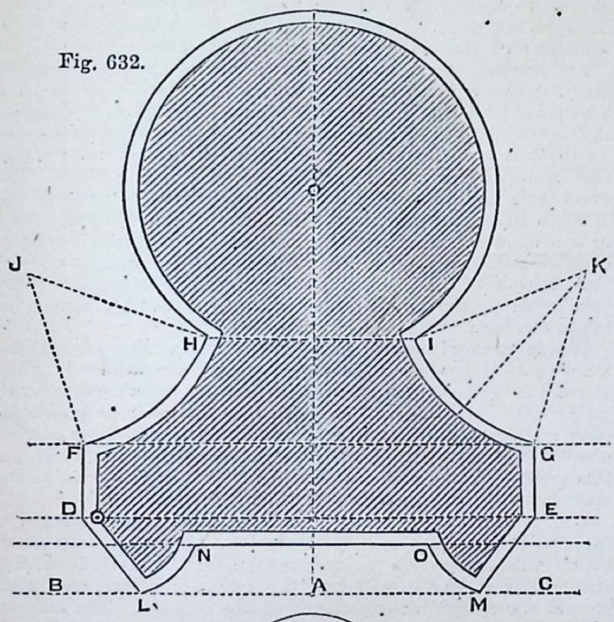
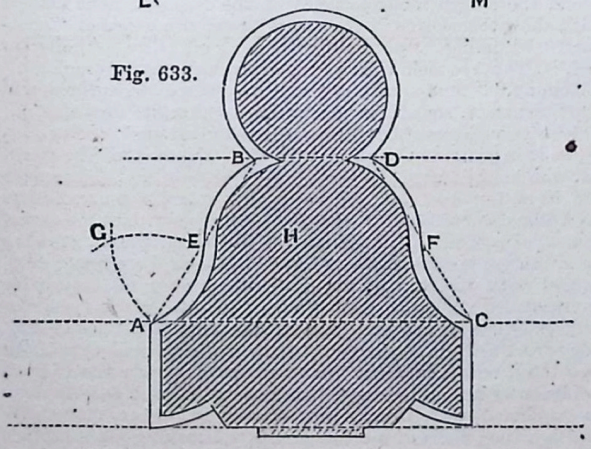


Fig. 633.



necessarily so, and it is a most important part of the work of the metal-plate worker to know the exact shapes into which metal is to be cut, so that when riveted, bent, or otherwise united, the object may be formed.

This portion of the subject is called development of surfaces.

We will in the first instance show the method of developing a cube.

Construct the square *a b d c* (Fig. 638), representing the base or any one side of the cube. Produce the sides of this square to *e, f, g, h, i, j, k, l*, and construct the squares *a e f b, b g h d, d l k c*, and *c j i a*.

At *k l* (or any other of the external lines) construct the square *k l n m*, which will complete the development, for it will be seen that if the squares *a e f b, b g h d, d l k c*, and *c j i a* were bent upwards, they would form four walls of a box, of which *a b c d* would be the bottom, and that the square *k l n m* would fold over and form the top or lid, parallel to *a b d c*.

Fig. 639.—In this figure is given the method of developing a triangular prism.

It is clear that this object consists of three rectangular faces and two triangular ends. Therefore draw the rectangles A B D C, C E F D, and E G H F, and at the ends of A B D C draw the equilateral triangles A C J and B D I, which will complete the required figure.

ENGLISH CARRIAGE-BUILDING.—IV.

BY A LONDON COACH-BUILDER.

CARRIAGE PAINTING (*continued*)—PERMANENT WOOD FILLING—PREPARATION OF BODY—FINISHING—GRINDING PIGMENTS—VARNISHING—LINING AND TRIMMING.

In resuming our directions for carriage-painting, it is worth while noticing here that a material has recently been brought into the English market, called "permanent wood filling," which is confidently recommended as effecting a saving in time, expense, and labour, and withal more certainly closing the pores of the wood than the ordinary filling now in use. This invention is due to a Polish exile, named Piotrowski, who took refuge in America, and there first introduced it in 1867, since which date it has found its way into the principal carriage factories of the United States. It is applied to the bare wood, one coat being given to bodies, and two to carriage parts. This closes the pores, holds the grain immovably in its place, and is so permanent in its effect, that neither exposure to dampness nor atmospheric changes, nor the vibrations to which a carriage is so subject, can act upon the grain. The satisfaction which this material appears to have given to our transatlantic cousins—who pride themselves upon the superiority of their carriage-painting—ought to induce our English coach-builders to inquire after it, for if all that we hear of it be correct, it must assuredly be a valuable acquisition in the paint-shop.

But, following the receipt given in our last paper, the body now receives a staining coat, after which it is well rubbed down with pumice-stone, and brought to a perfectly smooth surface. It is then carefully cleaned off, and receives two coats of dark lead colour made of tub lead, lamp-black, raw oil, and a small quantity of sugar of lead, and reduced to a proper consistency with Japan gold size and turpentine. One coat of this is applied per day, and after each coat the panels should be rubbed with fine sand-paper, and cleaned off. The dark surface that is now presented gives the painter a fair chance of seeing any scratch or imperfection that may be left on the panels, and which requires stopping up. After this has been attended to, the body is carefully faced down till a fine even surface is produced. Another coat of dark lead colour, the same as the last named, is then applied, and the body is ready for the ground colour.

Below we give a synopsis of the foregoing, that the painter may have a concise view of the entire process:—

PREPARATION OF BODY FOR COLOUR.

1 priming coat of lead (or leather parts, two coats of black varnish instead).
2 thin coats of colour. Stoppered up.
5 coats of filling-up (8 coats on leather parts).
1 staining coat. Rubbed down and cleaned off.
2 coats dark lead colour. Stoppered up. Rubbed down carefully.
1 coat dark lead.

12 coats, and ready for colour.

In the carriage parts two priming coats are first applied, which are worked the same as those used in priming the body. The cavities are then stopped with hard stopper, to which a little turpentine is added, in order to make it sand-paper easily. The wood parts then receive two coats of quick-drying lead colour, instead of dry lead and lamp-black ground in Japan gold size, and thinned with turpentine. The whole is then sand-papered down thoroughly, and the grain will be found to be well filled and perfectly smooth. A thin coat of oil, lead colour, is then added and well sand-papered, and any joints or open parts between the tire and felloes of the wheels are carefully puttied up with oil putty. The carriage parts are then ready for colour. Below is a synopsis:—

2 coats of lead priming. Stoppered up.
2 coats of lead. Sand-papered thoroughly.
1 thin coat of lead colour. Sand-papered and puttied up.

5 coats, and ready for colour.

To finish the body, we must proceed as follows :—

For the upper quarters and roof we must grind ivory black in raw oil, stiff, and add a little sugar of lead very fine for a drier, and thin to the required consistency with black Japan and turpentine. We must apply two coats of this, and then give two coats of black Japan, and rub down. Then face off the mouldings, and give a thin coat of dead black, after which apply a second coat of black Japan, and flat again. The whole should then be varnished with hard drying varnish, flatted down, and finished with a full coat of wearing body varnish.

If the body is to be blue, mix ultramarine blue with one-half raw oil and turpentine, stiff, and make of the proper working quality by thinning with hard-drying body varnish. Give the body two coats, and after each a slight flatting, then give two more coats of the same with varnish added. When Prussian blue is used, two coats are applied, and white is added if necessary, for the purpose of producing the required shade. The blues will dry sufficiently well when merely ground in raw oil, stiff, and reduced with turpentine, and it is better not to add any drier over blues, only one coat of hard-drying varnish should be given, and one finishing coat.

If the body is to be lake, the lake should be ground in raw oil, stiff, and reduced with turpentine and hard-drying varnish. The same with dross black and Indian red. Over lakes and greens two coats of hard-drying varnish should be applied, and one coat of finishing.

In no case should the painter allow his oil colours to dry with a gloss. He must always flat them, and give them the appearance of dead colour. This is particularly important in case rough stuff or quick-drying colour is to be used over it.

To finish the carriage parts, two coats of lead colour are first given, made the same as those given to the body before the application of colour. Then stopper-up with hard stopper, to which a little turpentine is added to make it sand-paper easily. Then give the wood parts two coats of quick lead, mixed of dry lead and lamp-black ground in gold size, and thinned with turpentine. The whole is next sand-papered thoroughly, when the grain will be found well filled and perfectly smooth. A thin coat of oil, lead colour, is next applied, and finally sand-papered, and at this point any joints or open parts between the tire and the felloes of the wheels should again be carefully puttied up with oil putty. A coat of colour varnish follows, then a second coat of the same, to which more varnish is added. All the parts are then flatted and striped, another light coat of clear varnish is given, and after being flatted down, the fine lines are added, and the whole is finished with a good coat of wearing varnish.

Such is the tedious process of painting, if we wish the work to be properly executed. In following all these details a great deal of time will be occupied, but the result will surely be satisfactory. In no case should the painting be hurried, for by allowing each coat of paint or varnish sufficient time to dry thoroughly before the next is added, the quality of durability is ensured. But in laying down these rules for carriage-painting, we have said nothing about the manner of producing the different colours. This is an art of itself, with which few coach-painters are acquainted. As a rule, they know little or nothing of the chemical qualities or affinities of the pigments they use; and for the production of the beautiful hues and shades which adorn the panels of our pleasure carriages, they are almost entirely dependent upon the manufacturer. While such is the state of knowledge in this branch of industry, it is to be regretted that the manufacturer can devise no better means than to give the material raw into the hands of the painter. Indeed, under any circumstances, it would be better if he could offer his goods ready for use; for in the process of grinding, the heat generated between the stone and the muller will often materially damage the hues of the delicate colours, and must, to a great extent, affect most of the pigments. Moreover, a great amount of time is expended upon an occupation that does not properly belong to the painter, and, in meting out quantity, a good deal of waste must necessarily be occasioned. To lessen the labour in this department, hand paint-mills have been largely introduced into our carriage factories. This is a step in the right direction, and has produced great advantages; but whether the grinding of colours is effected by stone and muller or by the improved paint-mill, the process is anything but cleanly, and the disagreeable effects of it are too patent to need much comment; and the painter constantly, for fear of providing himself with too little, very naturally prepares too much. It is objected, however, by our manufacturers, that colours cannot be ground and preserved in a liquid form ready to the painter's hand; but we learn from across the Atlantic that American invention has accomplished that which baffled English ingenuity, and that in New York pigments of every shade and hue are being so supplied, and with complete success. Mr. Masury, of that city, has produced machinery which enables him to grind pigments, even of the hardest description, to the most impalpable fineness, without in any way detracting from their purity or delicacy of hue, even when these are the most evanescent; and, by a process of his own, he preserves them so that the painter has nothing to do but to reduce them to the proper consistency and apply them to his work. We are at a loss to understand why so valuable an invention is not introduced into this country.

Another important question in relation to this department is that respecting varnish. After a coach-builder has exercised the greatest skill and care to produce and paint a carriage in the best style, it is no uncommon circumstance for him to see his finished work marred by the freaks of varnish, even when that material has been obtained from the best makers, and every care and precaution has been taken in the use of it. What is still more singular is, that varnish from the same can, in the hands of the same workman, will not always turn out equally satisfactory. These peculiarities have largely occupied the attention of the trade, and every variety of explanation has been given concerning them, but all these may be summed up in the one term, "atmospheric influence."

It may be very interesting, and even in some cases useful, to know that dampness of the varnish-room, the approach of a storm, the state of the atmosphere, mixing or otherwise tampering with varnishes, will cause them when used to go off in silky streaks, to pin-hole, to spot or to bloom; but there can be no solid advantage gained unless we can ascertain—why? When this question can be answered correctly it is quite possible we may arrive at prevention as well as explanation.

The defects of varnishes should be divided into classes—namely, those which exhibit themselves in the varnish-room before the carriage is pronounced finished, and those which occur after it has passed into the hands of a customer and beyond the control or experience of the builder. The defects which show themselves in the varnish-room are those of "spotting," "blooming," "pin-holing," "going off silky," "going in dead." Those which take place afterwards are "cracking," "blooming," "mud-spotting," and rapid loss of surface and impoverishment, sometimes amounting to absolute destruction.

These two classes should be considered separately, and assuming, as it is necessary to assume in such a case, that the workman who has executed the work is well skilled, and the varnish used is of the best quality, we should unhesitatingly dismiss this latter class of defects as not necessarily attributable to the varnish, except in the single case of blooming, which, as every one in the trade knows, arises from the atmosphere being overcharged with moisture, and is therefore only of temporary inconvenience. The best elastic varnish will crack from too great exposure to the sun, just as anything else may sustain injury from unfair treatment; the mud-spotting will arise from using the carriage in muddy or slushy roads before the varnish is sufficiently hard; the loss of surface will depend largely upon the coachman, who, from negligence or ignorance, may easily flat-down the panels of a carriage till the looking-glass surface entirely disappears; and impoverishment and destruction of varnish will commonly arise from the coach-house and stable being contiguous, the ammonia rising in steam from a stable being the most destructive chemical that varnish can be exposed to.

The other defects belong to the inherent nature of the varnish as at present manufactured, and, admitting the secondary cause to be atmospheric influence, it is necessary to inquire why it is that varnish should be subject to such influence. We do not pretend to penetrate the secrets of the trade, but according to the usual processes of making varnishes, we know that various metallic salts and chemical compounds are employed to increase their drying properties. All these will contain a certain definite amount of water, termed "water of crystallisation." If deprived of this water they lose their crystalline form, but they acquire a tendency of again assuming it, by attracting to themselves a proportionate amount of water whenever it is brought within

their influence. Now the heat employed in the manufacture of varnishes is sufficient to expel this water of crystallisation, and to cause these salts to become either dissolved or so thoroughly intermingled with the varnish as to have the appearance of a solution. Their presence is, however, sooner or later detected, for when the varnish is applied to the work the salts generally absorb the moisture which is always present more or less in the atmosphere to which they are exposed, and by becoming partially crystallised, cause what is known as "blooming," "spotting," and "pin-holing." The tendency to bloom will always remain, even after the varnish is thoroughly hardened, as we very well know; but if any one of these effects take place in the varnish-room while the varnish is drying, it is fatal to the appearance of the carriage. It follows, therefore, that if some substitute could be found for these objectionable dryers, not liable to atmospheric influence, we should get rid of these defects. Attempts have been made to substitute ozone or electrified oxygen gas, which has been largely introduced into many manufactories for its bleaching qualities, and is known also to possess peculiar properties as a dryer. After an article has been varnished the process of solidification to which we unphilosophically apply the term *drying*, is carried on by the absorption of oxygen gas from the surrounding atmosphere, and when the varnish is thoroughly hardened it has absorbed all the oxygen it is capable of, and the result is a beautiful transparent glaze. If these fine varnishes could be impregnated with oxygen in the course of their manufacture, their drying qualities would be facilitated without the use of the objectionable dryers now in use. It is found that they can be so impregnated with this gas in the form of ozone, but though experiments have been tried and favourable results produced, we are not aware that considerable success has yet been obtained, although we look to this discovery as offering great promise for the removal of the most tiresome and the most perplexing defects in varnishes.

We now come to the lining and trimming department, which is one also requiring great taste as well as skill. The interior of a carriage should be lined with cloth and silk, or cloth and morocco, with laces specially manufactured for the purpose; the colour should correspond to or harmonise with the painting. Light drab or fawn colour linings used to be very general for close carriages, such as broughams, because they at once afforded relief to and harmonised with any dark colour that might be selected for painting. But a severer simplicity of taste has prevailed of late years in this country, and the linings of carriages are mostly dark in colour, to correspond to the colour of the painting. This is often carried to such an extreme as to present an appearance of sameness and tastelessness. It is no uncommon thing, for instance, to see a brougham painted dark-green, striped with black lines, and lined with dark-green cloth and morocco, with plain laces to correspond. This, to us, appears only one degree removed from a mourning-coach, and we should be very sorry to see such a sombre taste prevail. On the other hand, we should pronounce violent contrasts quite contrary to all principles of good taste. Morocco and cloth, or silk and cloth, of the same colour as the painting should be selected for the lining; but as the painting should be relieved by lines that harmonise with it, so should the lining be relieved by the laces and tufts which are intended to give character to it.

SHIP-BUILDING.—XXV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

[METHODS OF LAUNCHING SHIPS—CONCLUSION.

In this, the concluding paper of our series, we propose to describe briefly some of the most common methods of launching ships, two of which are illustrated by Figs. 64 and 65. It is the termination of the work of the ship-builder, and vessels are often sent afloat before the boilers are placed in the hull, as in the case of steamers, or the masts are put in their places and the necessary rigging put up. It is generally a gay scene, owing to the preparations for the ceremony of naming the vessel. The operation of launching may be simply described as the sliding of the ship down one or more inclined planes into the water; but in the construction of these inclined planes, or "launching ways," and in the transference of the ship's weight to them from the blocks, very great care is required in order to ensure success. This will appear more clearly if we consider any particular plan, say that illustrated in cross-section by Fig. 64.

The blocks upon which the keel of the ship rested during her construction will be seen to have been removed, and the ship is now resting on two supports, one on either side of the middle-line. The blocks A, A are placed very closely, and carry a planked covering, S S, the two forming what is termed the "ground-way" or "sliding-way," which is continued out far enough in most cases to make the vessel "water-borne" aft when the stern has passed a moderate distance beyond the ways. The inclination of the sliding-ways is usually about seven-eighths of an inch to a foot, or rather more than that of the blocks upon which vessels are built; their upper surfaces are very often slightly curved or "cambered" instead of being true planes. Before the vessel can be supported upon these sliding-ways, the strong timber-constructions termed the "cradles" must be fitted (as shown) between the bottom of the ship and the sliding-way. These cradles stretch over something like two-thirds of the vessel's length, and, of course, move with her when she is launched. Their main features consist of a large timber (B), known as the bilge-way, resting upon the sliding-way; and of what may be termed the cradle-proper, extending between the bilge-way and the ship. In the amidship part of the ship the distance between the two would, of course, be small, and it is usually filled in solid with timber, known as the "stopping up" (which may be supposed to be nothing more than C enlarged). Forward and aft, where the ship becomes finer, it is preferable to use numerous timber struts, or "poppets" (P P), between the bilge-ways and the ship, and to connect them by suitable planks nailed to the sides of the poppets, as roughly indicated in the sketch. Means have to be taken also to keep the heads of the poppets firmly fixed in their proper positions, when the enormous weight of the ship is brought upon them.

The bilge-ways are usually about one-third of the extreme breadth of the ship apart; and the whole of the arrangements described above are fitted in place while the ship continues to rest upon the blocks and the shores. The ribbands, R R, are secured to the sliding-ways, and strongly shored to the sides of the ship, in order to prevent the bilge-ways from moving further apart when the weight of the ship is brought upon them; and short shores are fitted between the bilge-ways and the keel for the purpose of preventing any closing in of the bilge-ways. Care must be taken in proportioning the surfaces of the bilge and sliding ways to the weight of the ship to be launched, and in all cases these bearing surfaces should be well greased not long before the launch takes place.

When the "launch" or "cradle" has been fitted, the pieces are separated, and the bilge-ways are taken out of place or "turned out." After the operation of greasing the ways has been finished, the bilge-ways are "turned in," and the cradle is re-erected and secured in place; this is usually done on the day before that fixed for the launch. Next, it is necessary to transfer the weight of the ship to the cradle; this is done by "setting up," or driving in wedges between the bilge-ways, B, and the timber, C, thus forcing the cradle tightly up under the bottom. The blocks and shores can then be removed, but it is not customary to complete this part of the work until the time immediately before the launch.

When completed, the ship is held in position only by the "dog-shores," which commonly consist of short lengths of timber placed in an inclined position, heeled against the fore-ends of the ribbands (R, R) on the sliding-ways, and butted against cleats strongly bolted to the sides of the bilge-ways. At the moment of launching the fore-ends of the dog-shores are knocked down (by the fall of weights or other means) clear of the cleats, and the vessel is left free to move. Sometimes there is a difficulty in making her start, and then her motion is aided by means of hydraulic presses, shores, etc. etc., applied against the stem. In other cases, ships have stopped on the ways, sometimes in very awkward positions, straining the hulls severely. With these occurrences, however, we have no concern, and we shall assume the launch to be perfectly successful, the vessel gradually moving down the ways with an increasing velocity, until her stern enters the water, and quickly becoming water-borne aft before the bow is clear of the ways. When

there is plenty of room, vessels are allowed to go free, until their motion is checked by the resistance of the water; but when launched into narrow creeks or channels, other means must be taken to "bring them up" within the limits desired.

The cradle, of course, may be expected to detach itself, and to rise to the surface when the ship is afloat, but care should always be taken that no parts of the launch—such as poppets, etc.—remain under the bottom. In the case illustrated by Fig. 64, there would be some pieces actually fastened to the bottom to secure the heads of the poppets, and to remove these the vessel must be placed in dry dock. Many merchant vessels, however, are completed before being launched, and proceed on service immediately after, so that it would be impossible to carry out the plan of Fig. 64 in its entirety. A simple device suffices to meet such cases, for the cradles on opposite sides can be efficiently secured by means of chains passing underneath the keel, without attaching any pieces of plank to the bottom.

Another method of launching is shown in Fig. 65, and needs but brief description. It requires only a central sliding-way under the keel, the piles G, G, G being fitted not for the purpose of supporting the vessel, but in order to prevent her from falling over on her side when being launched, an occurrence that is not uncommon when precautions are not taken. Hence the upper surfaces of G are not fitted closely against the lower surfaces of H H, but are at a little distance from them. The method is said to answer well, and it is less expensive than the preceding, as the timbers H, H are all that need to be specially fitted to a particular ship, and the remaining pieces can be used for all ships. The French have long made use of this plan of launching on the keel; but in the Royal Dockyards of this country, the method illustrated by Fig. 64 is universally adopted.

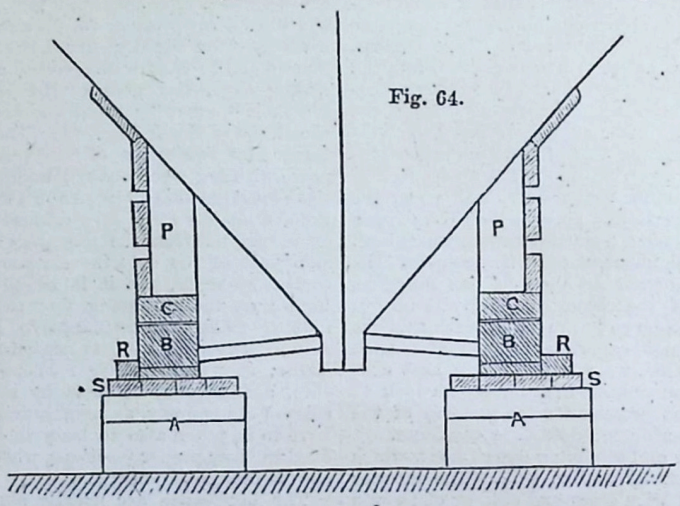


Fig. 64.

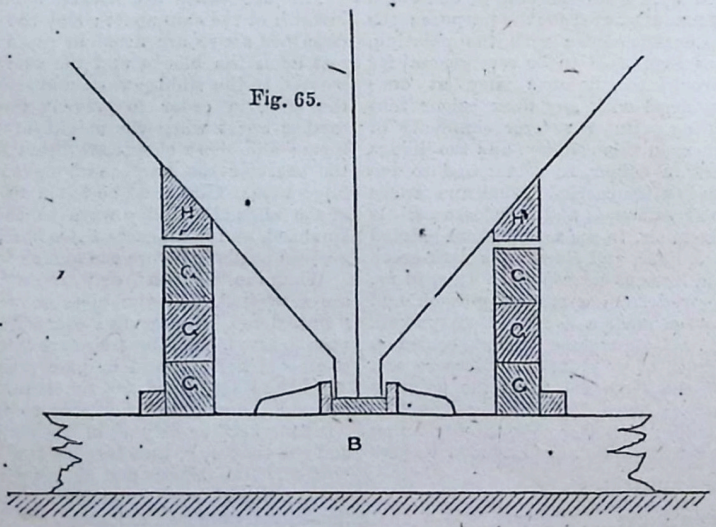


Fig. 65.

All the foregoing remarks apply to the commonest cases of ships built end-on to the water. When ships are launched sideways into the water, the sliding-ways are often made more numerous, and special forms of cradles are constructed clasping the ship transversely. This was the principle adopted in launching the *Great Eastern*. There were two broad sliding-ways, and an equal number of cradles; only in that case, instead of having the bearing surfaces of the launching ways of wood, and greasing them on the usual plan, there were iron bars bearing on iron bars. To this departure from the common plan, and the consequent decrease of the area and change in the character of the bearing surfaces, the failure of the first attempts to launch the vessel, and the great difficulty experienced in getting her into the water afterwards, are probably attributable.

In concluding these papers on Ship-building, we would remind our readers that only the main features of the subject have been considered, it having been impossible within the limits assigned to enter into details on any of its branches, or even to mention some important matters intimately associated therewith. For example, the *processes* of ship-building, involved in the preparation of the various parts of a ship, have not been touched upon; although they include the methods of "taking account of work" (to use a shipwright's phrase), the construction and use of moulds, the shaping of frames, beams, planks, plates, etc. etc., and many other features of interest. Nor have we been able to describe the qualities of the materials used in ship-building, the modes of testing their fitness for use, the special requirements for particular services, and similar points of importance. Then, too, the question of "laying-off" has been merely mentioned, although it is a most extensive one, and involves the whole practical geometry of ship-building. And if other instances were needed of the unavoidable incompleteness of our treatment, many might be given.

Throughout, our aim has been to supply some knowledge of the principles which underlie all proper ship-construction, as well as to illustrate the principal structural arrangements of various classes of ships. So far, we trust, we have not been unsuccessful; and at least it may be said that the information given includes many of the most recent and improved methods of building ships. The information which we have not had the opportunity of furnishing here can be obtained by those persons desirous of acquiring it from the extensive treatises on practical ship-building, in wood, iron, and steel, now accessible; wherein will also be found detailed descriptions of many arrangements of which we have only given the outlines.

From the preceding papers it will have become obvious that the knowledge required by the ship-builder is most varied and extensive, including not merely the principles of structural combination, but also an acquaintance with chemistry, galvanism, and many other branches of physical science. It will also have appeared that many and great improvements have been introduced within the last twenty or thirty years, and that other important changes seem close at hand. These improvements become more remarkable when it is considered that they have almost entirely originated with British ship-builders, and have had a great effect on the relative standing of both our mercantile and war navies, as compared with those of foreign nations. Our supremacy on the seas is of vital importance; it involves our keeping the lead in all branches of ship-building, and the applications thereto of the allied arts and sciences. At the present time our lead is probably greater than it has ever been. To retain this superiority will doubtless require an effort as years pass by, and other nations benefit by our experience and example; but so long as the disposition of our ship-builders to advance both in the theory and practice of their profession continues strong, there seems little reason for fearing competition in this great branch of the national industry.

MINING AND QUARRYING.—XXXIII.

BY GEORGE GLADSTONE, F.C.S.

COBALT.

DISTRIBUTION — ORES — OXIDE OF COBALT — USES — MANUFACTURE OF SMALT AND ZAFFRE—THEIR USES—THENARD'S BLUE.

THE two metals to which the reader's attention is invited in the present article do not occur to any great extent in the British Isles, but their uses are of sufficient importance to call for a brief notice of them. Some of the ores, moreover, which contain them are imported into this country in the raw state, and here prepared for use.

Cobalt is found at times in Devonshire and Cornwall, in mining for tin and copper, and in the cupriferous rocks of Alderley Edge, in Cheshire, and of some parts of Ireland. It is generally in combination with arsenic or sulphur, as arsenical or cupriferous pyrites, and is not very easily detected by its external appearance; so that there are well-authenticated instances of cobaltiferous ores having been thrown aside as worthless by those miners whose scientific education did not extend beyond the most ordinary requirements of their calling. A remarkable case of this kind occurred at the Mucross copper mines in Killarney, where a valuable ore of cobalt, which was abundant there, was rejected as rubbish, and one of the miners, who was wiser than his masters, managed to secure for himself a quantity of this rejected stuff.

Nevertheless, it can be infallibly detected by the use of the blowpipe, on fusing any of its compounds with borax for a few moments, when a beautiful and characteristic blue bead will form on the loop of platinum.

The ores of greatest importance occur in Saxony, Silesia, Bohemia, Norway, and Sweden; and it is in these parts of the Continent that the largest and most important works for converting them into a commercial article are found.

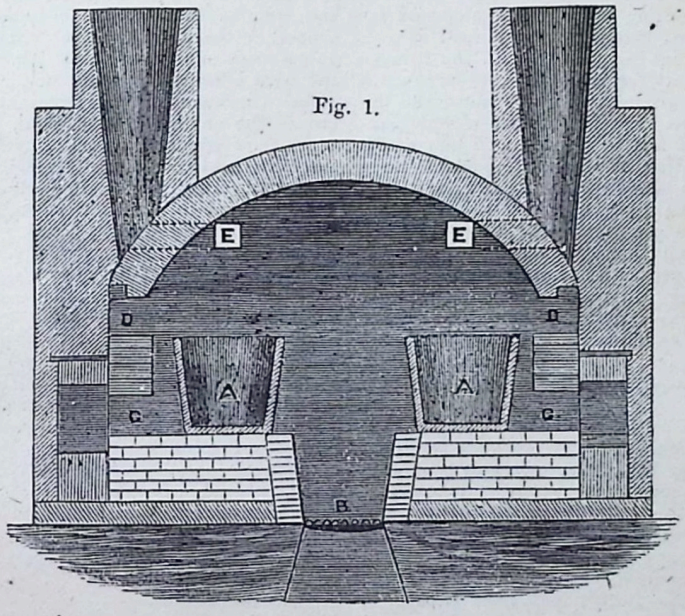


Fig. 1.

The metal itself does not occur in nature, and can only be reduced with difficulty from its ores. Moreover, it is of no economic value in its metallic state. No attention is therefore given to reducing it to this condition; the object of the metallurgist being to produce the oxide and the silicate, which are the compounds of greatest value in the arts. There are some other salts, such as the nitrate, phosphate, chloride, and sulphate, which have a limited application.

The oxide of commerce is prepared by smelting the ore, after separating by hand as much of the matrix as possible, and then calcining the regulus which is thus produced. On being withdrawn from the furnace, the calcined article is dissolved in hydrochloric acid, and the iron and arsenic contained in the solution are subsequently precipitated by the gradual addition of milk of lime. The sulphides are next thrown down by passing sulphuretted hydrogen through the solution, and the liquid then remaining is drawn off, and the cobalt is precipitated from it by the addition of chloride of calcium. The hydrated oxide of cobalt which is thus obtained is then submitted to a red heat, when what is known as the blue oxide is produced; or to a white heat, the product of which bears the name of prepared oxide.

These are used by potters to a considerable extent, for giving a bluish colour to their manufactures. A superior article, used in enamelling and in the best class of goods, is made by boiling up the raw ore in nitric acid, which causes the arsenic usually present in the ore to combine with whatever other metals there may be mixed up with it. These arseniates being all less soluble than the arseniate of cobalt, can be thrown down in succession by the gradual addition of the alkaline carbonates; and the proper time to suspend the operation can be easily recognised by the rose colour yielded by the cobalt salt.

It is the silicate, however, which possesses the greatest commercial importance. The familiar name of it is smalt; certain qualities are known as azure and ultramarine, the former an indefinite, and the latter a misleading term; and these are again subdivided into ordinary, middling, fine, superfine, etc.; the differences between which can only be learnt by practice.

In the manufacture of smalt the first thing to be done is to separate from the ores the earthy portions, and those metallic compounds which do not contain cobalt. The ores are therefore reduced to small pieces, and well picked over; they are then ground fine and washed, which separates the earthy matters, but leaves all the mineral constituents as they are usually of equal specific gravity to the cobalt compounds. The result is generally of very mixed composition, containing iron, copper, tin, or any other of the metals common to the district where the ores were raised. The next step of the process is to convert the levigated ore into an oxide, and at the same time to separate those metals which may be associated with the cobalt, or to reduce them to such a condition that they shall have no power to destroy the beauty of the blue colour, upon which the value of smalt depends. This is done by roasting it in a reverberatory furnace, the only special features of which are the long flues, which are made first to encircle the furnace, and then to pass into a long, wide gallery, sometimes called the poison chamber, where the arsenic of the ores, which has been converted into arsenious acid, is gradually deposited. The quantity of this poisonous substance is usually very large, as many of the ores contain from 45 to 75 per cent. of arsenic; and it would be both wasteful and injurious to the health of the workman if this were allowed to escape into the air. In Germany the roasting is generally performed in winter, as the cold favours the deposition of the acid. The roasting should not be carried so far as to drive off the whole of the arsenic, because in that case there is a danger of some of the other metals becoming oxidised, which would interfere with their ultimate separation.

The next thing to be done is to convert this roasted ore into a silicate. For this purpose it has to be fused with the ingredients necessary to constitute a glass, and the fusion should be so conducted as to remove the useless or objectionable ingredients in the dross. Potash is always used as the flux, as lime, soda, and magnesia all impair the richness of the blue colour. It is calcined prior to use, to purify it, and to drive off all the moisture which it may have absorbed. The quartz used has also to be carefully purified, for which purpose it is heated to redness, pulverised, and then washed and re-heated. The relative proportions of ore and quartz which should be used are determined by trials on a laboratory scale, and one-third of their united weight will be the quantity of potash to add; to these must also be added some arsenic about equal in weight to the ore. This last ingredient is used just in the condition in which it is taken from the galleries already described, where it

is deposited from the roasting. These materials are well mixed together in troughs, and from them the mixture is transferred to the pots in which it is fused.

The melting pots are carefully made of refractory clay, and thoroughly dried and annealed before use, as they will have to bear an intense heat. The interior surface of the pots is glazed with an inferior quality of smalt. They are set in a furnace somewhat similar in construction to that of a glass-house. The accompanying diagram represents the cross-section of a round one, with two of the pots in their place. These are marked with the letters A, A, and there are usually eight of them in each oven. The fire-place, B, is in the centre below the floor, and is fed from the outside; the draught passes up from the ash-pit, and carries the flames up into the vaulted chamber. C, C are called knee-holes, which are opposite to a small opening near the bottom of each pot, which is closed up during the melting, but through which the contents are withdrawn when the operation is complete. The working holes, D D, are at a higher level; through these the charge is introduced, and the mixture stirred occasionally during the melting with a red-hot poker. Sometimes also the glass is withdrawn through these in iron ladles. The waste gases pass out through the flues E, E, into the chimney. The knee-holes are kept closed until the fusion is complete, and the working holes are only opened for inserting the charge and stirring it during the melting; as soon as this stage is reached they are kept closed, and the furnace maintained at a full white heat for some time, to produce a perfect combination of the ingredients, and to allow the impurities to separate themselves. On the surface a little sandiver generally collects, which has to be skimmed off; and a compound called speiss, consisting of various impurities, sinks to the bottom. If the glass is ladled out through the working-holes, the workman has to take care not to let the speiss get mixed up with the rest; if the pot is tapped the speiss flows out first, and is removed, and then the pure blue glass is allowed to flow into the bath prepared for its reception. The glass, immediately on its being withdrawn from the pots, and while yet red-hot, is thrown into cold water, the sudden cooling caused by which breaks it up, and renders it so brittle that it can easily be ground to powder. The speiss consists of an alloy of cobalt, nickel, iron, arsenic, bismuth, and sometimes other metals.

The grinding of the glass is conducted under water between two mill-stones; and after they have been at work for some hours, the water in which they have been revolving is allowed to run into a succession of receivers to settle. The purest smalt, being the heaviest, will soon sink to the bottom, and then the water is drawn off into the second receiver, where the next quality will be deposited, and so on until the whole of it is collected. The precipitates are subsequently washed thoroughly, to secure the greatest possible purity, and then packed in casks.

The chief use of smalt is in making blue glass, and in producing a deep blue design in porcelain, earthenware, etc. It is also used as a pigment, and for neutralising the yellowish tint which paper, linens, calicoes, and other articles would otherwise possess. Scientific investigators also often avail themselves of glass coloured by cobalt, as it cuts off the luminous rays of the sun to a great extent, without interfering with the rest of the spectrum.

Zaffre is also much used by the manufacturers of earthen and glass wares for producing a blue colour. It consists of a mixture of the roasted cobalt ore and flint, both ground to a fine powder, the relative proportions of which are so adjusted that they will produce a glass of a certain tint when fused with alkali. The various qualities and tints of both articles are known by the marks acknowledged in the trade.

Thenard's blue is a very beautiful colour which is also used to some extent. It consists of two parts of the phosphate of cobalt, and one part of the arseniate, mixed with sixteen parts of alum, and then burnt.

NICKEL.

GEOGRAPHICAL DISTRIBUTION—ORES—SEPARATION FROM COBALT SPEISS—FROM COPPER ORES—ALLOYS—THEIR USES—ELECTRO-PLATING—MAGNETISM—METEORS.

Nickel is found in still less quantity than cobalt in this country, though some small per-centage of it may often be found in copper and other ores. Germany and Austria are the great sources of supply.

The pure metal is ductile, and of a brilliant white colour: it is scarcely used except in its metallic state. It is derived from kupfernickel, which is a compound of this metal with arsenic; from nickeliferous pyrites; and from cobalt speiss, which usually contains a considerable proportion of nickel, as these two metals are very much associated in nature. It is from the latter article that this metal is principally obtained in this country.

The speiss is fused with chalk and fluor spar, and the product is then ground up and roasted to expel the arsenic. It is then dissolved in hydrochloric acid, and the iron and any arsenic still remaining in it is precipitated by the action of chloride of calcium and milk of lime. Sulphuretted hydrogen is then passed through the solution, which will throw down the other metals contained in it, with the exception of the cobalt and nickel. The former of these will be separated by the addition of some more chloride of calcium, and lastly the nickel in the state of an oxide by adding milk of lime.

It will be seen from what has gone before that both cobalt and nickel have a great affinity for arsenic, and from this last operation that they have very little for sulphur. Advantage has been taken of this circumstance in copper-smelting, as copper, on the contrary, has a strong affinity for sulphur, and only a weak one for arsenic. Mr. Vivian therefore introduced the plan of separating the small per-centages of cobalt and nickel which are frequently present in copper ores, and which impair the quality of the metal, by introducing a sufficient quantity of arsenic or arsenical pyrites, to convert the whole of the nickel and cobalt into arsenides, while the copper is converted into a sulphide. After being melted, the copper regulus will be found to overlie the arsenical compounds, which have then to be separated and purified.

Nickel enters into alloys with some of the other metals, producing compounds of very considerable utility. Some of these are known under the general name of German silver, which is largely used as a foundation for silver plating. It can readily be detected at the points of forks, or wherever the pure silver is exposed to rapid wear, by the yellowish shade of the alloy as compared with the other. The colour, however, varies according to the relative proportions of the metals of which the alloy is made, the best qualities being scarcely inferior in brilliancy to silver itself. Forks and spoons, and other articles of domestic use, are often made of such compounds without being subsequently plated; they also answer well for the manufacture of mathematical instruments.

The following table gives the per-centage proportions of various alloys of nickel, with the special characteristics of the several combinations:—

Nickel.	Zinc.	Copper.	Character of Alloy.
15	26	59	This is about the most inferior preparation. If a smaller quantity of nickel were used, the alloy would tarnish rapidly.
20	34	46	A compound common in China, called Tutenag. It is very fusible, but at the same time very hard. It rolls badly, but makes very good castings.
21	24	55	A good mixture, having the appearance of silver which is somewhat below the standard.
24	19	57	These proportions make an alloy which rolls well. If 3 per cent. of lead is added, it will be very suitable for castings.
25	25	50	A very suitable proportion for the usual plated goods.
26	23	51	A decidedly superior article. It closely resembles silver in colour and brilliance, and it is less liable to tarnish.
34	20	46	This is about the largest proportion of nickel that can be used. It is hard to work, and fusible with difficulty.

In China another alloy of nickel is made, the native name of which is Pakfong—white copper. It has been found on analysis to consist of 31·6 per cent. of nickel, 25·4 of zinc, 40·4 of copper, and 2·6 of iron.

Nickel is now used to some extent as a substitute for silver in the electro-plating of goods. The metal is deposited from a

solution of the sulphate or chloride, and produces a brilliant surface.

The pure metal is magnetic, and may therefore be substituted for steel in making magnets; it has the advantage over the other metal in being unaffected by the moisture of the atmosphere.

The majority of meteors exhibit a natural alloy of iron and nickel. As much as 8½ per cent. of the latter has sometimes been found in them. Such meteoric iron, if cut and polished, will retain a bright surface with ordinary care, as nickel possesses the power of greatly retarding the rusting of iron.

CIVIL ENGINEERING.—XXII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES.

It is now necessary to introduce our readers to one of the most important of all engineering structures, whether regarded in a military or civil point of view—the bridge. The history of bridges necessarily dates from a remote period, for the indispensable character it possesses for all purposes of locomotion would justly lead us to infer that no people could ever have attained to a high degree of civilisation without some more ready means of crossing the streams by which their country would be intersected than by boats.

As may be supposed, the kind of structure employed as a bridge varies, and has varied to a very great extent. We need not travel far in order to see bridges of almost every type, from the magnificent iron roadway across the Thames at Southwark, or the substantial stone thoroughfare at London Bridge, to the miserable and dangerous wooden fabric at Putney. Indeed, scarcely a stream of any consequence exists in our own country over which in some part of its course are not to be found bridges of almost every description, from the exquisite and well-proportioned curve to the unsightly flat girder. Each, however, has its use, and our intention is to point out the principles upon which the several kinds of bridges are constructed. In our last chapter we drew attention to the method of gaining a substantial base by means of piles, and we now pass on to consider the superstructure reared thereupon.

The most natural, and at the same time the earliest, method of placing over a stream some permanent means of crossing it, is to throw over it a slab of stone or a beam of wood, resting the ends on the banks, which have been previously cut down to a uniform level. The slabs or beams may be of any number to suit the breadth of roadway required, laid side by side, with planks placed across them. There must, however, be a limit to the breadth of the stream which can be crossed by such a bridge, and a limit, moreover, to the load which such a structure could support; but it may, nevertheless, be assumed that such bridges have been common in all ages, and should the breadth of the stream be such as to preclude its being crossed by a single beam, it might easily occur to the mind of the self-taught engineer that a prop or support driven into the bed of the stream—should the depth permit it—might be made available for resting the extremities of two beams end to end upon it, and thus a stream of double the breadth might be crossed.

We purpose dividing the subject into distinct parts—*i.e.*, wooden bridges, stone or masonry bridges, iron bridges, and suspension bridges.

A wooden structure, such as we have alluded to, may assume a form of the most primitive kind, the strength of such a bridge being, of course, simply comparative with that of the breaking strain of the beam; the stronger the beam the stronger the bridge. A little thought will, however, show that a beam perfectly equal throughout as to its section will involve a waste of material, and for the following reason. If a rod or beam be subjected to strain either laterally or end-ways, the ends being supported, it will yield most in the centre, its *absolute* strength being assumed equal throughout; and if it breaks under a load or a thrust, it will break at or near the middle. Now, the obvious method of rendering a beam under these conditions of uniform *resisting* strength throughout, will be to increase its strength in that part which experiment proves will first give way—the centre. Assuming, then, that the weakest portion of a beam for resisting purposes, supported at its extremities, is the middle, it may be inferred that its strongest portions will be close to its points of support: such is the case, and hence a beam or rod, to have uniform resisting strength throughout, should be thickest in the centre, and should taper away gradually to the ends. Hence, having ascertained the requisite dimensions for the central portion, it becomes a useless waste of material to retain equal dimensions throughout.

The same principle is involved in the case of carriage springs, where the weight of the carriage rests upon the centre of the spring, the ends being supported, only that in this case the uniform resisting strength is gained by adding additional thicknesses of spring towards the centre; and this arrangement becomes the most convenient in the case of the bridge alluded to, building up the central portions as shown in Fig. 49, by bracing together extra beams where more strength is needed. In this primitive arrangement the strength of the compound beam is equal throughout for resisting purposes. Such a mass of timber is, however, both unsightly and unnecessary, for by the introduction of struts, as shown in A A′ (Fig. 50), the weakest portion of the beam is supported. The struts may rest upon stone projections made in the piers, the other ends abutting against each other. The support thus afforded at the point B is proportioned to the strength of the struts themselves, the vertical strain at B being transferred into the diagonals indicated by the arrows parallel to the struts, and received upon the projections C, D; hence the piers themselves become the recipients of the entire load resting upon the horizontal beam. The tendency of the thrust on the struts is to buckle them, and therefore a tie-beam, as shown at A in Fig. 51, may with great advantage be introduced. Thus step by step we become aware of the value of the various timbers introduced into all structures which have to support a weight in a given direction; and it is only by a careful consideration of the real direction of strain that the several supports are placed just where they will best serve the purpose intended. These forms of construction of timber bridges are very far from constituting the only kinds of such structures. The diversity to be met with is very great. Timber of sufficient length cannot always be found, and hence some arrangement of the struts to meet the difficulty must be adopted. An instance occurs at Lyons, where a bridge is thrown across the Rhone. In Fig. 52 is shown the arrangement of the timbers in this structure. Here the support is given at the intermediate points A, B, C, D, and E, and the necessity for the long strut from C to C′ is avoided.

By the adoption of a framed rib, as shown in Fig. 53, as great an amount of strength is gained as in the arrangement Fig. 52, and a lighter-looking structure results. Lattice-work girders, now so commonly met with in iron bridges, are, however, by no means confined to iron, and in America are to be found several noteworthy instances of timber lattice-work bridges spanning very wide rivers in that country.

An elegant adaptation of lattice-work, known as Long's, is much employed in America. It consists, as shown in Fig. 54, of a series of St. Andrew's crosses between vertical posts, the posts being securely bolted at their extremities into the horizontal timbers. Here the thrust lies in the direction indicated by the arrows, whilst at the same time the girder itself is possessed of great strength. The depth of the framing must be proportioned to the distance between the piers.

An important modification of the timber bridge is shown in Fig. 55, where the strength of the girder is increased by resting it, either from above or below, upon rods or chains of iron, A A′, the thrust being delivered by the vertical pieces 1, 2, 3, 4. This constitutes a form of suspension bridge, the vertical strain being transferred to the rod A A′, and the load-bearing strength of the span being proportioned to the tensile strength of the rod.

The true curve may be theoretically regarded as consisting of a polygon whose sides are infinite in number and infinitely short, arranged in the line of curve. Hence, if we regard the arch as the strongest of all forms for a bridge, the nearer we approach it the stronger will be the resulting structure. The straight line or girder bridge is as far removed from the arch as possible, and hence it has the least strength, independently of the framework or absolute and inherent strength of the thing itself. The simple struts (Fig. 50) break the straight line, and become the next step in the acquirement of strength. In Fig. 52 another side is added to the polygon, and in Fig. 53 the sides are still further increased in number, with proportionate advan-

tage. The introduction of bent timber, as shown in Fig. 56, brings us at once to the arch. Here, so long as the bent portions are kept efficiently tied, the greatest amount of strength is obtained.

A powerful combination of timbers in which curved work is introduced is obtained by the introduction of vertical as well as inclined struts, as shown in Fig. 57. The timbers which form the arch are scarfed, care being taken that no two scarfs occur between the same pair of principals. The various courses of bent timber are firmly united between each principal by bolts and nuts, *a*, *a*, *a*. A timber arch, constructed upon this arrangement, may be made of very considerable span; but in all timber bridges of large span, it is necessary to bear in mind its tendency to horizontal movement. This must be guarded against by every possible means. The inclined struts become of value in this respect by preventing any movement of the principals, and at the same time securing the necessary rigidity in the flooring. In all timber structures there is a greater or less risk of movement of the parts from the imperfection of the workmanship, as well as from the shrinking and warping of the timber itself; hence a settlement of the arch may be anticipated and prepared for. A formula for the lowering at the middle in bridges of fir timber has been given, derived from observation. It is $\cdot 02 \frac{f}{c}$, in which *c* represents the opening of the arch, and *f* its settlement immediately after building; it increases, however, by subsequent alteration of the timber.

In our previous examples we have described timber bridges in which the supporting timbers abut against the walls, and exercise a thrust. It is possible, however, to prevent this, and to confine the thrust to the tie-beam itself, as in Fig. 58, where the struts are mortised into it. Such a combination forms a very strong arrangement, the entire frame being complete in itself.

The flooring or roadway of timber bridges should be protected as much as possible from the action of the weather, and from the damage arising from traffic. If covered with soil, unnecessary weight is added, and dampness, which is prejudical to the stability of the timber, is retained. For these reasons, a false floor is preferable, as it can be easily remedied without detriment to the main structure. Advantage will also be found in covering the main roadway with a sheeting of lead or copper, the expense being only in the first outlay, with a subsequent saving, consequent upon the greater durability obtained.

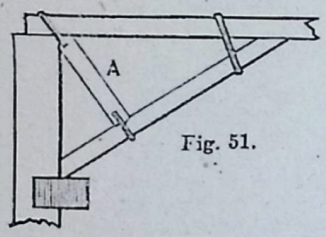


Fig. 51.

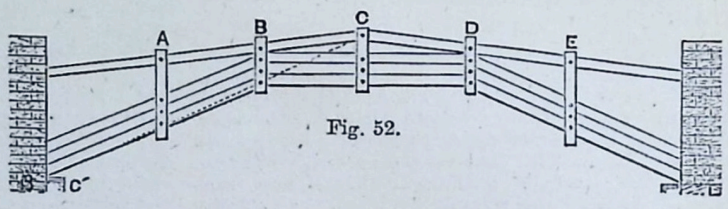
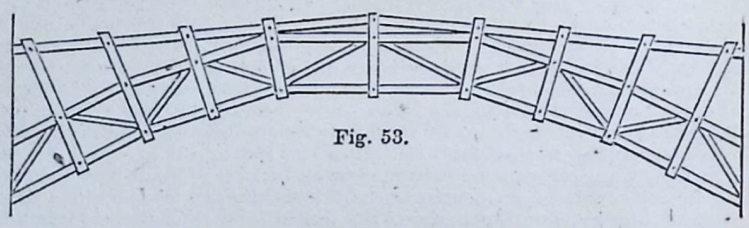


Fig. 52.



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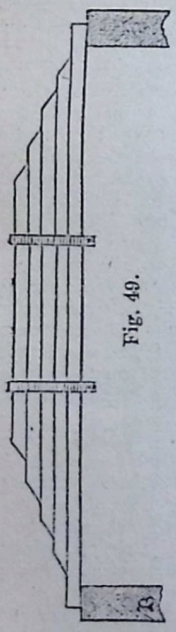


Fig. 49.

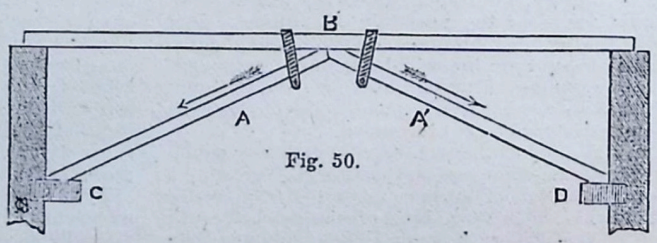


Fig. 50.

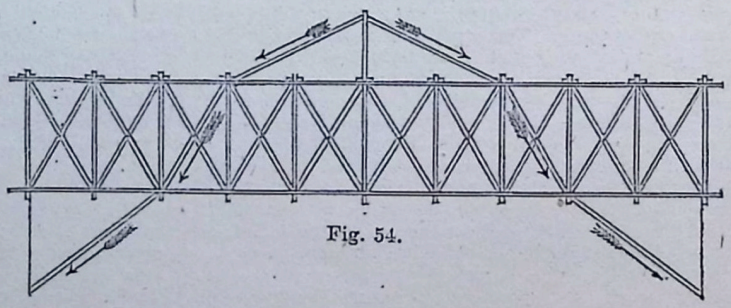


Fig. 54.

Timber becomes a very useful material for the construction of foot-bridges. In Holland a considerable variety of such bridges occurs over the numerous canals which intersect that country. In Figs. 59 and 60 we give two instances, the first occurring over the canal of Gouda, having a span of 45 feet; the other, of the same span, over the canal at Utrecht. A valuable combination of struts is to be seen in a bridge over the Loire, of three arches, each 92 feet span. It is shown in Fig. 61. The arch is formed of a polygon, five sides of which appear between the abutments. The angles formed at the points of union of these sides meet in the centre of corresponding timbers placed over them, and the pendant binding pieces are securely braced.

We cannot omit an interesting and early instance of the application of the suspension principle to a timber bridge which was built over the Durance. This bridge had a span of 115 feet. The centre bay was held up by four radiating posts

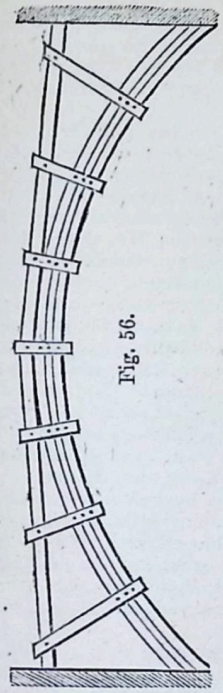
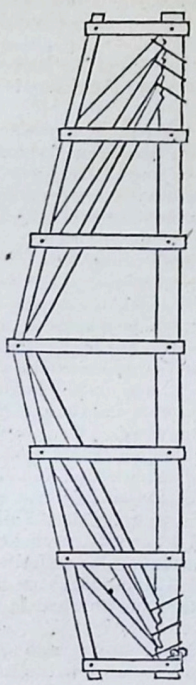


Fig. 56.



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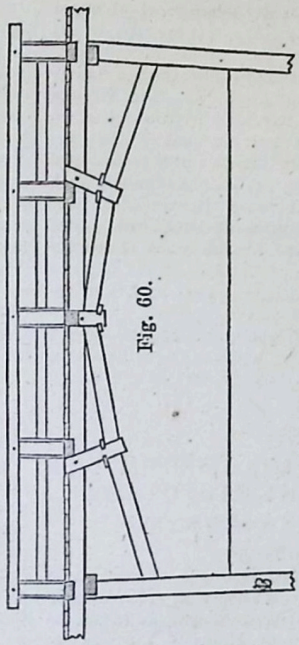

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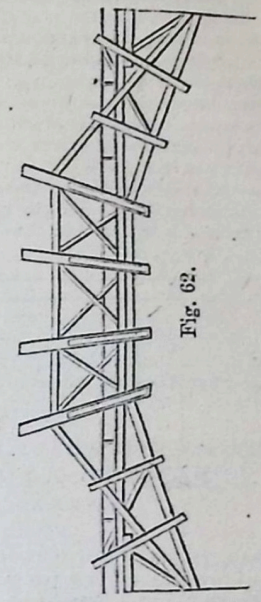


Fig. 62.

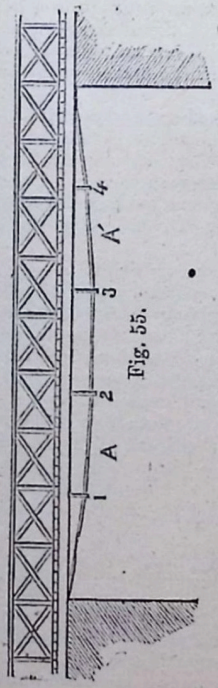


Fig. 55.

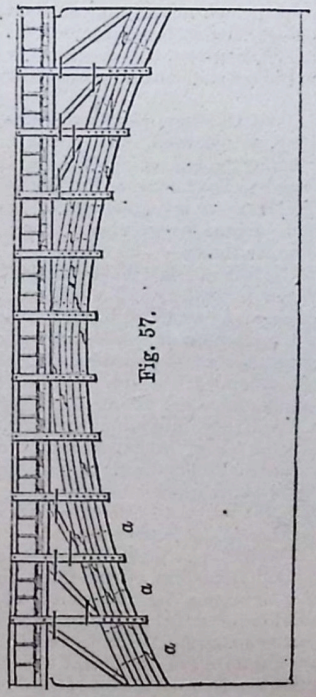


Fig. 57.

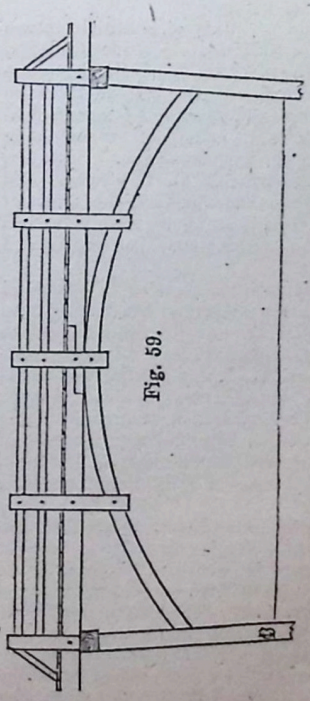


Fig. 59.

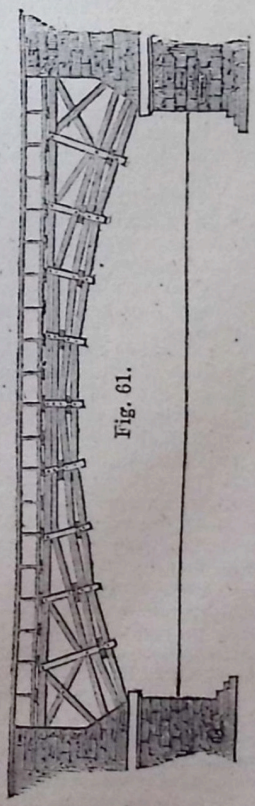


Fig. 61.

(Fig. 62), kept in their position by horizontal timbers and St. Andrew's crosses, the whole forming, as it were, a framed key-piece, supported at its extremities by inclined struts resting on the abutments, the struts bearing against both the heads and the sills of the suspension posts.

In America, where timber is readily obtainable, timber bridges are to be found in great variety, and many of them of large dimensions. A timber bridge was built in 1804 over the Delaware, at Trenton, which consists of five arches of different span, and crosses the river where its width is 1,100 feet. The roadway is suspended from the arch by vertical iron rods, placed in some cases 8 feet apart, and in some 16 feet. The joists which carry the roadway fit into stirrups at the lower end of the rods. A still larger timber bridge of the same character occurs over the Susquehanna, in Columbia. It consists of twenty-nine arches, each 200 feet span, supported on two abutments and twenty-eight stone piers.

In the instances we have given of timber bridges we have by no means exhausted the subject, for bridges constructed of this material are to be found in almost every part of the world, of an almost endless variety of type.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XL.—RENÉ DES CARTES.

BY JAMES GRANT.

THE inventor of the Cartesian system, as it is called, René Des Cartes, than whom few philosophers have a higher claim to distinction, was a Frenchman, and native of Touraine, where he was born in 1596, during the reign of Henri IV., a stormy period of French history, and two years before the famous Edict of Nantes became law.

While a child, he acquired the sobriquet of "the young philosopher," from the eager curiosity he displayed to inquire into and discover the nature and causes of things. In the year 1604 he was committed to the care of a learned Jesuit, under whose tuition he made uncommon progress, and displayed a wonderful aptitude for proficiency. He soon began to discover defects in existing systems, and hoped to be the means of giving to science an aspect at once new and more pleasing.

After having spent five years in the study of polite literature and of languages, he entered upon a curriculum of morals, logic, and mathematics, according to the methods in which they were taught during the sixteenth century. With these methods he was disgusted, or rather so perplexed, that he determined to form for himself a system of rules, or canons of reasoning, in which he followed the method of the geometricians. However, after all, he was so little satisfied with his own progress and attainments, that he left college, lamenting that the fruits of eight years' close application and hard study were only the full conviction, that as yet he knew nothing with clearness and certainty.

He even threw his books aside with a resolution to pursue no other knowledge than such as he could find within himself and in the great volume of Nature. At the age of seventeen he was sent to Paris, and there the love of pleasure for a time overcame all desire of philosophical distinction. It was the Paris of Henri IV., and morality at that period was at a somewhat low ebb, for in that year the king obtained a sentence of divorce from his queen, with the public and avowed intention of marrying one of his mistresses, whom he had created Marchioness of Verneuil, but was induced, by the remonstrances of Sully, to marry Marie de Medicis.

A chance introduction to some learned men recalled the attention of René Des Cartes to mathematics, and this science he again prosecuted in solitude for two years, after which he resolved to become a soldier, and in 1615 he entered the army of the States of Holland as a volunteer. The Dutch were then engaged in a quarrel with the Elector of Brandenburg and the Duke of Nieuburg, concerning the joint possession of the duchies of Juliers and Cleves; but the prospect of a serious war passed away, and Des Cartes, while in the Dutch service, wrote a "Dissertation to prove that Brutes are Automata."

From the service of Holland he passed into that of the Duke of Bavaria, William, a strong supporter of the Jesuits; but wherever René went he conversed with learned men, and notwithstanding his coat of mail and harquebuss, appeared rather in the character of a philosopher than that of a soldier.

At last he grew weary of wandering, and, quitting the army in 1622, he returned to his native country, with no other profit, as he said, "than that he had freed himself from many prejudices, and rendered his mind more fit for the reception of truth."

In Paris he fixed his residence, when Louis XIII. had been twelve years on the throne, and then he resumed the study of mathematics, in hope of discovering the general principles of relations, measures and proportions, applicable to all subjects, by means of which truth might, with certainty, be investigated, and the limits of knowledge be extended. He turned his attention from mathematics to ethics, and attempted to raise a superstructure of morals upon the foundation of natural science, as he conceived that there could be no better means for discovering the true principles of action, than by the contemplation and study of our own nature, and the nature of the world around us; and as the result of these reflections and inquiries, he wrote a treatise upon the human passions.

Having spent some time in Italy, whither he had gone in pursuit of knowledge, he returned again to Paris, and from thence he went again to Holland with the view of founding a new system of philosophy; and there he chose retirement as the best means of forwarding the object he had in view and the plans he hoped to execute. While employing himself in the investigation of a proof from reason, independently of revelation, of the fundamental principles of religion, and publishing his "Philosophical Meditations on First Philosophy," he pursued at the same time his physical inquiries, and published a "Treatise on Meteors."

To medicine, anatomy, and chemistry he paid considerable attention; and he also wrote an astronomical treatise on the system of the heavenly bodies, which he suppressed on hearing of the vile and unjust treatment which Galileo had met with for his discussion on the same subject, as related in THE TECHNICAL EDUCATOR, page 54, Vol. II.

The Cartesian system of philosophy was first taught in the schools of Deventer, a town of Holland in the province of Over-Yssel, the native place of the philosopher Gronovius, and where Erasmus was a student; and in England it obtained so much credit that the inventor was invited by Charles I., and some of the principal nobility, to settle there, an invitation which he would probably have accepted, had not the storm of the Great Civil War prevented the king from being able to extend to the philosopher all the patronage which he had formerly offered him.

About this time Des Cartes was lured or provoked into many angry, yet learned, disputes, in the course of which, as well as by his collateral conduct, he evinced an earnest desire to be viewed as the father or founder of a sect; and thus was alleged to discover more jealousy of others, and more personal ambition, than became so great a philosopher. On the subject of logic, he wrote thus:—

"Nothing is ever to be admitted as true which is not certainly known to be so, and which cannot possibly be doubted. In proving any truth, the ideas are always to be brought forward in a certain order, beginning with things the most simple, and by regular steps advancing to those which are more complex and difficult." Concerning metaphysics, he says, that since man is under the influence of prejudice, he ought, *once* at least in his life, to doubt of everything, even whether sensible objects have a real existence, and also of the truth of mathematical axioms. The first principle of the Cartesian philosophy is this, "*I think, therefore, I am:*" this is the foundation of his metaphysics; and the structure on which his physics is built is, "*that nothing exists, but substances.*"

The latter he made of two kinds; the one that thinks, and the other that is extended, so that thought on the one hand and extension on the other make the essence of substance. Having thus fixed the essence of matter in extension, Des Cartes concluded that there is no vacuum in Nature, nor any possibility of it; but that the universe is absolutely full. By this principle mere space is quite excluded, for extension being implied in the idea of space, matter is so too.

Motion he defined to be the translation of a body from the neighbourhood of others that are in contact with it, and considered as at rest, to the neighbourhood of other bodies. By

this hypothesis he destroyed the distinction between motion that is absolute or real, and that which is relative or apparent. He maintained that the same quantity of motion is always preserved in the universe, because God must be supposed to act in the most constant and immutable manner, and hence he also deduced his three laws of motion.

"Upon these principles Des Cartes explains mechanically how the world was formed, and how the present phenomena of nature came to arise. He supposes that God created matter of an indefinite extension, which he separated into small square portions or masses full of angles; that he impressed two motions on this matter; the one by which each part revolved about its own centre; and another, by which an assemblage, or system of them, turned round a common centre. From whence arose as many different vortices or eddies, as there were different masses of matter, thus moving about common centres. . . . Now the first or most subtile element, according to the laws of motion, must occupy the centre of each system, or vortex, by reason of the smallness of its parts; and this is the matter which constitutes the sun, the fixed stars above, and the fire below. The second element, made up of spheres, forms the atmosphere, and all the matter between the earth and the fixed stars; in such sort, that the largest spheres are always next the circumference of the vortex, and the smallest next its centre. The third element, formed of the irregular particles, is matter that composes the earth and all terrestrial bodies, together with comets, spots in the sun," etc.

During the residence of Des Cartes in Holland, he went occasionally to his native country, where in 1643 he published an abstract of his system of philosophy, under the title of "Philosophical Specimens;" and on one of these visits he was promised an annual pension of 3,000 livres, which he never received.

Christina, the Queen of Sweden, invited him to visit Stockholm. That learned princess had read with avowed pleasure his treatise "On the Passions," and was earnestly desirous of being instructed by him in the principles of his philosophy. In obedience to her invitation, he arrived at the Swedish capital in 1649, at a time when refinement and literature had made but little progress among the warlike Swedes, whose martial spirit was then at its height, after the long Thirty Years' War; but he received a warm and friendly welcome from the young queen, who urged him to settle in her kingdom, and assist her in the formation of an academy of sciences.

Des Cartes had only been four months in that northern climate, when, in a severe season, during one of his visits of instruction to the queen, he caught a cold, that brought on an inflammation of the lungs, which put a period to his existence in 1650. His remains were interred in the common cemetery set apart for all foreigners near Stockholm, and a long eulogium was carved upon his tomb; but in 1666 his bones were exhumed and transported to France, and solemnly deposited with all the circumstances of pomp in the Church of St. Geneviève at Paris—not the present Pantheon in the Rue St. Jacques, but the older fane in which the saint herself was deposited in the sixth century, and which was only demolished in the beginning of the present century. His remains, however, probably lie undisturbed in the subterranean church.

Of René Des Cartes many eulogia have been published by persons capable of appreciating his worth.

In his "Opuscula" Dr. Barrow observes that Des Cartes was doubtless a very ingenious man, a real philosopher, and one who seems to have brought those assistances to that part of philosophy relating to matter and motion, which perhaps no one had done before—namely, a great skill in mathematics; a mind habituated by nature and custom to profound meditation; a judgment exempt from all errors and prejudices; an entire disengagement by his own choice from the perusal of useless books, an incomparable acuteness of wit, and perspicuous power of expression. Dr. Halley, in a paper on Optics, says he was the first who in modern times discovered the laws of refraction, and brought dioptrics to a science; however, Dr. James Keill, the celebrated Scottish astronomer and mathematician, took a different view of him, and asserts that Des Cartes was so far from applying geometry and observation to natural philosophy, that his whole system is one continued blunder, on account of his negligence in that particular point, which he could easily prove by showing that his theory of vortices, upon which his system is founded, is absolutely false.

"Recueil de quelques Pièces curieuses concernant la Philosophie de M. Descartes," appeared in 12mo at Amsterdam in 1694; and a complete edition of all his works, in eleven volumes 8vo, was published at Paris by Victor Cousin in 1824-6.

OPTICAL INSTRUMENTS.—XXII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN.

Its History.—The invention of the magic lantern has been ascribed by some authors to Friar Bacon, on account of an old Oxford legend which relates, that he had been seen walking in the air between two steeples, "which was thought to be done by glasses when he walked upon the ground:" this would carry the discovery of its principles back to about the year 1260. From a graphic description given by the celebrated Florentine engraver, Benvenuto Cellini, of a necromantic ceremony performed by a Sicilian priest at the Colosseum, which lasted above an hour and a half, whereat legions of devils seemed to fill that vast amphitheatre, others have referred its discovery to the early part of the sixteenth century, as Cellini speaks of trying to quell the intense fear and horror of his companions by telling them "that all these demons are under us, and what ye see is but smoke and shadow;" thus indicating his personal knowledge of an optical origin for such frightful visions. A declaration made by a boy who accompanied Cellini on the occasion is further suggestive of the optical arrangement employed, for he states, "As we were going home to our houses in the Quarter Banchi, *two of the demons whom we had seen at the Amphitheatre went on before us*, leaping and skipping, *sometimes running upon the roofs of the houses and sometimes upon the ground!*" Cellini, it may be mentioned, died in 1570. It was not till the seventeenth century, however, that a definite account of the construction of the "Magic Lantern" was given to the world, in a Latin work entitled "Ars Magna Lucis et Umbræ," or "The Great Art of Light and Shadow," by Athanasius Kircher, a Jesuit living at Rome, who was born in 1601.

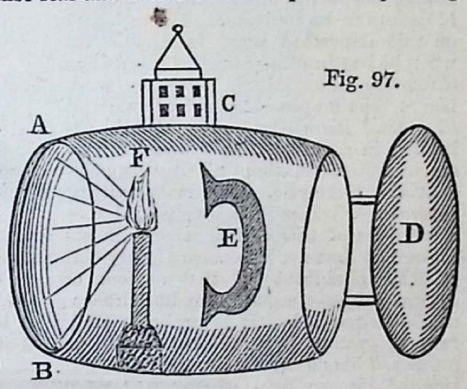


Fig. 97.

Kircher ascribes his knowledge of this instrument to a mathematician named Thomas Walgenstenius, a Dane, who constructed magic lanterns and sold them as rare curiosities to the Italian princes and other wealthy and learned people. Such lanterns appear to have been cumbrous and rudely made. In the first edition of Kircher's "Ars Magna Lucis et Umbræ," published at Rome in 1646 by Ludovici Grignani, a rude engraving (copied in Fig. 97) represents a barrel-shaped lantern, one end being filled up with a concave reflector, A B, which projected the rays of a wax taper, F, through a double-convex lens, D, the slide being inserted in the opening between the front of the lantern and the lens, and the smoke carried off by a chimney, C. This arrangement was portable, and could be carried by handles, E, fixed to the side. Its object, it is stated, was to show an inscription on a wall at a distance from the lantern. In the second edition of this work, published at Amsterdam in 1671, Kircher gives the result of his knowledge acquired from Walgenstenius, his descriptions being illustrated by two beautifully executed engravings, one of which is copied in Fig. 98. This represents a large square wooden box, or rather a chamber, some six feet square, with a door on one side, fitted with a tube, C, that carried the painting and lens, or lenses; the source of light was an oil lamp, L, with a polished brass reflector placed behind the flame. This lamp was fixed beneath a chimney fitted to the top of the box to carry off the smoke, and from Kircher's representation the lamp appears to have

been a very smoky one, devoid of anything in the shape of a lamp-glass or chimney. Kircher's slides consisted of rude figures of spectres, skeletons, demons, etc., painted on glass, within circles, three or four subjects being painted on one slide. This chamber was separated from the room in which the spectral images were shown on a smooth whitened wall by a partition, through a hole in which the rays from the lantern passed. Now it will be observed, that though a lens corresponding to the modern condenser is represented at C, no indication is given in this drawing (or in the fellow-representation) of any power or magnifying lens. It is quite obvious that the light collected by C passing through the slide could only give such a shadowy picture as light passing through a stained-glass window projects. Did he form his image by means of a very small hole in the partition? As this method with such a poor light would give anything but a satisfactory result, it is more probable that a magnifying lens was fixed in the hole in the partition to attain the amount of definition he indicates. His reticence on this important point is remarkable, when he has in other respects given such elaborate illustrations, and his work shows that he possessed a large amount of optical knowledge, while he also exhibited in numerous other works a vast amount of information on scientific, antiquarian, linguistic, and mathematical subjects. Kircher for a long period gave exhibitions of this optical novelty in his room at the Jesuits' College at Rome, which were nightly thronged by the noble and wealthy inhabitants of that ancient city. Most authors on optical subjects seem to credit Kircher as the inventor of the magic lantern; but it is probable that that instrument took form by gradual improvement till the period at which Kircher published his description of its arrangement in his "Ars Magna Lucis et Umbræ."

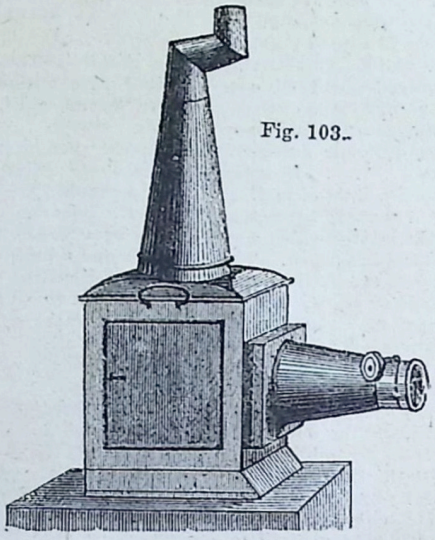
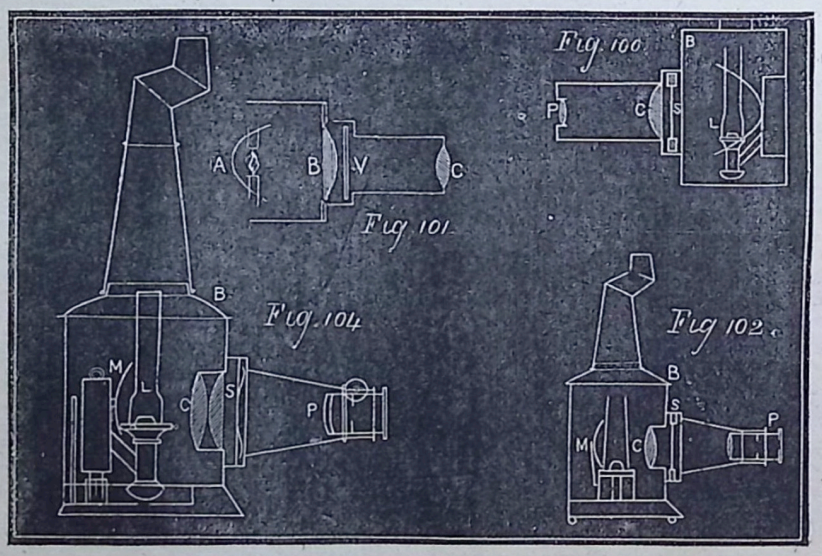


Fig. 103.

As specula and lenses were known to the ancient Egyptians, it is not improbable the learned priests of the temples availed themselves of such optical aids to minister to their acquiring power over the minds of the people and even the mighty of the land. We can imagine the priests availing themselves of the intense illuminating power of a tropical sun, in some such arrangement as that described by Schottus and shown in Fig. 99. In this O represents a metallic speculum, on the face of which was written words suited for the requirements of the occasion of any manifestation in a temple. This lettered speculum was affixed in reverse position to the wall of a yard on which the rays of the sun, S, could fall, such speculum being opposite to and in focus with a lens, L, let into the wall of a temple facing the altar at which the manifestation was to appear on a screen of drapery, D, placed in the conjugate focus of the lens L, and consequently in the position where an image, I, of the object, or words on the speculum O, would be projected. We can imagine as the next step towards an improvement on this crude arrangement that the speculum would be replaced with an opaque sheet of metal, etc., out of which the letters or object could be cut, as in a stencil plate, and the sunlight reflected through it; next that the orifices in the plate should be covered over with transparent coloured papers; then that the light of the sun would be replaced with an artificial source of light, such as that of a lamp fed with fat, to which would next be added a concave mirror, the prototype of the lantern condenser—for few would imagine, unless they had tried it, how bright a picture can be produced by concentrating the light on the slide by means of a concave reflector only—an important advance, as the necromantic manifestations to which the lantern lent its aid could then be called into play at any time required, more especially "at the witching hour of night." Next, the stencil plate would give place to rough paintings on glass, and we should find the arrangement much as Kircher described it in the seventeenth century, shown in Fig. 97, and possibly such as Cellini's friend, the Sicilian priest, employed at the Coliseum some fifty years before Kircher's *séances*, for from Cellini's narrative it may be surmised that the lantern used on that occasion was portable, and consequently more compact than Kircher's lantern, as shown in Fig. 98.

Not much advance could be expected from that date till the introduction in 1789 of the circular wicked burner, with central air-way, oxygenating cone and glass chimney, by Aimé Argand, the inventor of the "Argand lamp." To the Argand burner was added the parabolic reflector, the most perfect collector of light, when properly constructed. An additional means of concentrating the light was gained by the introduction of a glass "condenser;" this at first was placed between the picture, S, and magnifying lens or "power," P, and in focus with the flame of the lamp, L, as shown at C in Fig. 100; afterwards the stage for the slides was placed between the condenser and power, and close up to the former, as shown in Fig. 101, which at B may be regarded as the type of modern lantern construction. The condenser has been used in the form of the "bulls'-eye," the "double-convex" (the best form for pictures not over 2½ inches in diameter); the "double condenser," wherein two lenses are used in place of a single lens; and the "triple condenser," composed of three lenses. The magnifying part has been rendered more efficient by the employment of a combination of two lenses in place of the single "double-convex," so as to reduce the amount of spherical and chromatic aberrations, and render the optical system perfect by making the power achromatic in conjunction with condensers of short focus, and of such curves as yield a flat and colourless field. The sources of light have been improved on by the adoption of the oxy-calcium, oxy-hydrogen, magnesium and electric light to suit the requirements of the exhibitor, and the entire instrument has been rendered perfect by carefully devised arrangements for making it compact, portable, and so ready to the hand of the exhibitor, that all its parts and accessories may, in the course of a few minutes, be unpacked,



and placed in position for work in any room, and be packed and removed as quickly. Further, the attention that has of late years been given to the improvement of the magic lantern has raised it from the position of a mere nursery toy to that of an important physical instrument of the greatest educational value, especially when employed in conjunction with photographic slides, whether produced from natural scenes and objects, or artistic drawings of subjects not attainable direct from nature, according to the system previously advocated at pages 244, 275, Vol. II., of THE TECHNICAL EDUCATOR.

The Choice of a Lantern.—Magic lanterns are offered to the public in a variety of sizes and qualities, ranging in price from five shillings to fifty pounds, so that the uninitiated often feel a difficulty in making selection of a useful instrument; but the range, practically, is very limited. In the first place, the purpose for which it is required must be determined; in the next place, the amount to be expended.

If a toy is required for the nursery, "a child's lantern," with twelve long slides in a box, can be purchased for 7s. 6d. Such a lantern would be fitted with a single condenser of $1\frac{1}{2}$ inches diameter, and $2\frac{1}{2}$ inches focus, with a double-convex power of $2\frac{1}{2}$ inches focal length, which would give a sufficiently bright disc of 3 feet diameter at 6 feet distance from the screen. "The Guinea Lantern," with a box of a dozen long sliders, is well suited for a Christmas box; this gives a 4-foot disc at 6 feet from the screen, with a condenser of $2\frac{1}{8}$ inches diameter and $2\frac{1}{2}$ focus, and a double-convex power of 3 inches focus. If a useful instrument is desired, one that can be added to from

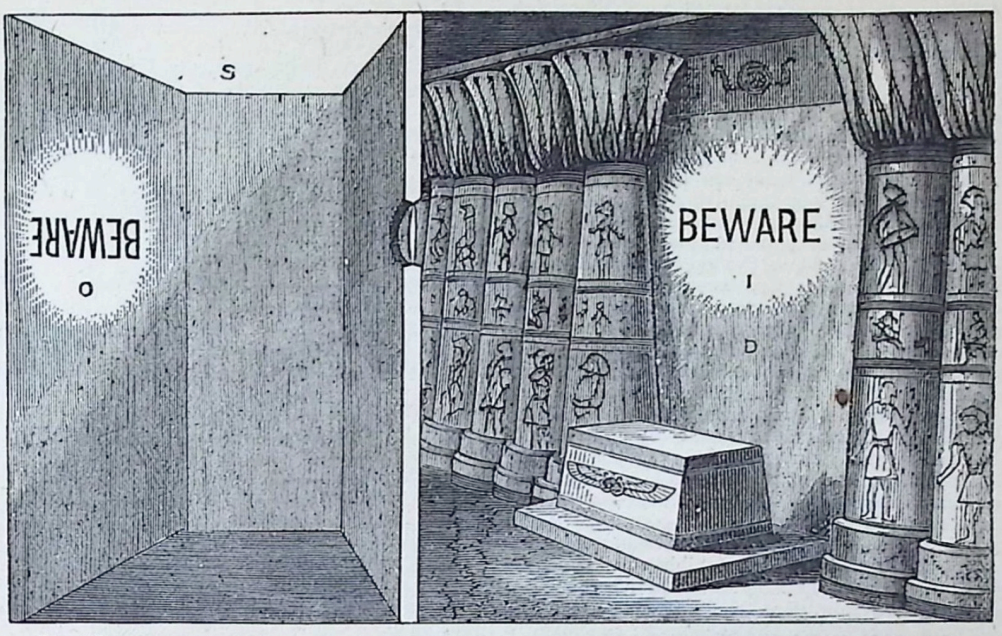


Fig. 99.—SUPPOSED USE OF THE PRINCIPLES OF THE MAGIC LANTERN BY THE EGYPTIANS.

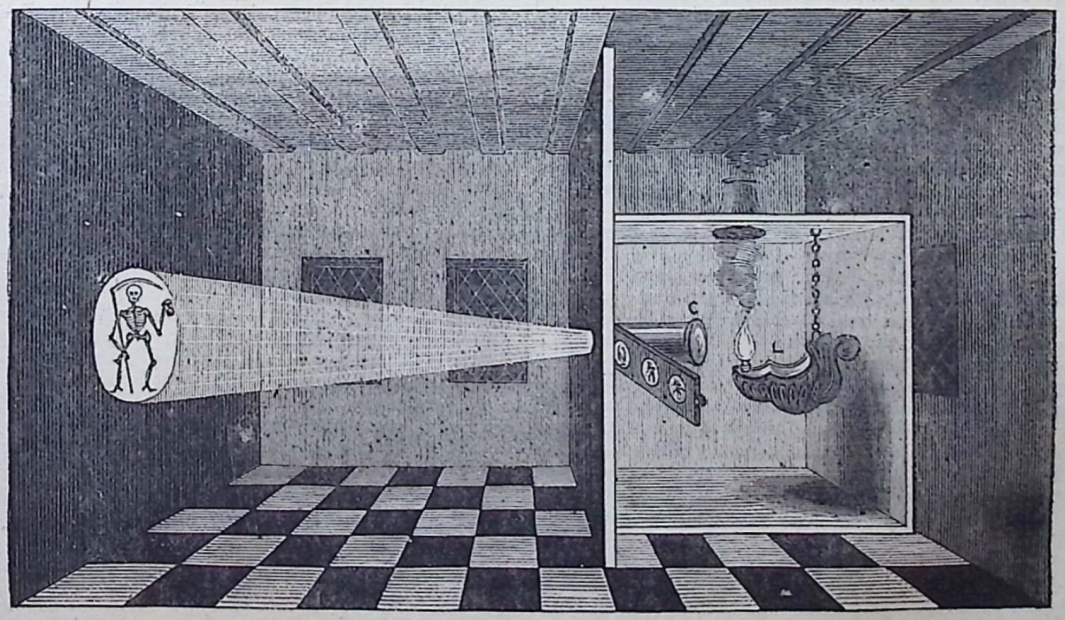


Fig. 98.—THE MAGIC LANTERN AS EXHIBITED BY KIRCHER.

time to time, and be made a source of varied amusement, wherein action can be given to the figures and mechanical and chromatropic effects produced, then the cheapest lantern that can be purchased is "The School-boy's Magic Lantern," for showing 2-inch pictures, and the smallest size of comic slip slides, chromatropes, etc., which may be bought for about a guinea and a half without slides. This lantern has a condensing lens of $3\frac{1}{8}$ inches diameter and 3 inches focus, with a plano-convex power of $3\frac{1}{2}$ inches focal length, which yields a disc of 6 feet diameter when placed 10 feet from the screen, the lamp in this case being of Argand construction, as shown in Fig. 102. As, however, a disc of glass only 2 inches in diameter does not present much scope for producing any artistic effect, it is undoubtedly cheaper in the long run, where cost is not a matter of grave consideration, to purchase a thoroughly good instrument in the first instance, wherewith to show slides of 3 inches diameter, which, since the application of photography to the production of magic-lantern slides, may be regarded as *the standard size* for lantern views, for those of greater diameter only involve a more cumbrous apparatus, without a compensating result, and further, a considerable additional expense, as slides of greater diameter than 3 inches are seldom kept in stock by opticians. Slides over 3 inches have therefore to be produced to special order, which consequently involves a delay in getting supplied, unless a selection of subjects be given many months before such slides are required for the winter season, on account of really artistic slide-painters being *very* limited in number, and those who bear the palm in this profession always having their time fully occupied. Artistically painted slides of 3 inches diameter demand an arrangement of superior construction for their exhibition, wherein the source of light should at least be a fountain Argand, such as is shown in Fig. 86, page 324, and Figs. 91, 92, page 365, Vol. III. of THE TECHNICAL EDUCATOR; the condensers composed of two lenses of $3\frac{1}{8}$ inches diameter (as the condenser should always be at least half an inch larger than the greatest diameter of the picture to be shown by it), and 3 inches combined focus, and the power formed of a combination of two meniscus lenses of 4 inches combined focus, which gives a flat field with tolerable definition in the image, though not quite free from chromatic fringes. Such an arrangement is embodied in "The Family Phantasmagoria Lantern," which gives a 9-foot disc at 9 feet from the screen, which instrument is the stock article of the shops, and is purchasable for about three guineas. As this may be regarded as the typical arrangement for ordinary use, I have shown it in perspective in Fig. 103, and in section in Fig. 104. As will be seen hereafter, the term "phantasmagoria" is a misnomer, that term being only properly applied to a lantern of more complicated mechanical construction for the purpose of making the image rapidly increase or diminish in size, and seem to approach or recede from the spectators.

Before concluding the present article, I may here state that the four lanterns previously described are really very cheap, as they are made wholesale in very large quantities, by a few manufacturers who supply all the London and provincial shops of sellers of optical goods, whether they be opticians pure and simple, or those who combine the sale of optical wares with pharmaceutical preparations, tooth-brushes, bears' grease, perfumery, cutlery, watches, jewellery, or toys, whose optical knowledge is of as visionary a character as the images produced by the magic lanterns they dispose of in the same spirit as they would Dutch cheeses, or the razors made famous in Peter Pindar's poems. Beyond this point the magic lantern may be considered in the light of an educational and physical instrument, for showing with the greatest perfection geographical, historical, and scientific diagrams, or optical, acoustic, and thermotic demonstrations in the lecture-room. The selection of an educational lantern depends upon the exact purpose for which it is required, and its cost upon the amount of attention given to its construction, and details of arrangement to render it perfect for a demonstrator's requirements. As the demand for such instruments can only be of a limited nature, they are of necessity more costly than those previously described. The various arrangements can best be described under "systems" of apparatus and appliances, as "The School System," "The Photographer's System," "The Demonstrating System," "The Dioramic System," after first entering into the principles of lantern construction.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. GALLETLY, Curator, Industrial Museum, Edinburgh.

III.—HISTORY OF WOOL AND WOOLLEN MANUFACTURES FROM THE FIRST TO THE SEVENTEENTH CENTURY.

NOT much is known concerning the extent to which woollen fabrics were made during the early centuries of the Christian era. In Greece, Italy, Syria, and other countries on the Mediterranean where a high degree of skill in many arts had been long acquired, the textile industries appear to have been in an advanced state. Constantinople, whither the Greeks had carried their handicrafts in the fourth century, was especially famous for its woollens. Claudian, writing at this time, mentions clothing made of beavers' skins, which Beckmann thinks must have been spun and wove, as attempts had been previously made so to manufacture the fur of the hare. Another fabric, made with the warp of beavers' fur, and the woof of goats' hair, is noticed by Isidorus, who lived in the early part of the seventh century. At a later time the Emperor Nicephorus II. wore an upper garment of this cloth at his coronation. During the Middle Ages, whatever perfection had been achieved in the arts before the fall of Rome, was preserved chiefly at Constantinople, then the capital of the Byzantine empire; and from thence workmen skilled in weaving and other industries found their way to Italy at the time of the revival of learning and the arts. Thus it was that in the thirteenth century woollen manufactories were established at Florence, Rimini, and Perugia. These appear to have rapidly extended in number, and enjoyed considerable prosperity; but after mentioning the fact that mohair fabrics were made at Perugia as early as the fourteenth century, we proceed to trace the history of woollen textiles in those northern nations where such manufactures took deeper root.

There is evidence, which appears to be all but conclusive, that in pre-historic times the inhabitants of Great Britain practised the art of weaving, and no doubt wool must have been the material used. Primitive tools of bone, resembling metal ones still in use in India, instead of a "reed" for weaving some fabrics, have, at all events, been frequently found in Picts' houses. But the first recorded notice of the production of cloth on any considerable scale on British soil, relates to the establishment of a woollen manufactory at Winchester, during the time of the Roman occupation. It is supposed that from this factory the Roman army was supplied with clothing; at any rate it was not long before it or other British factories furnished some of the finest and most costly robes worn in Rome itself during the most luxurious era of the empire. There is little doubt that the wool employed for these fabrics, and described by one Roman writer as producing yarn so fine "that it is in a manner comparable to the spider's web," was obtained from native sheep. It is supposed that owing to the disturbed state of the country for several centuries during the time of and after the Roman occupation, the manufacture in Britain declined, although at Winchester it did not cease to exist. Nothing is known as to what change it produced in the clothing of the natives, but from the few and scanty references to the subject among our early writers we may conclude that, even in these times, the preparation of woollen yarn had become a favourite domestic occupation among them, and that the value both of the woven fabric and the material it was made of, as a source of national prosperity, was beginning to be understood.

In the year 712 the sheep is expressly mentioned for the first time in British annals, but only to refer to its price, which was one shilling of Saxon money until fourteen nights after Easter. Towards the close of the ninth century, the mother of Alfred the Great is described as being skilled in the spinning of wool; and referring to Edward the Elder, Alfred's successor on the throne, Fabian's Chronicle says that, being anxious his children should receive a proper education, "he sette his sons to scole and his doughters to woll werke." It appears, too, that Edward's first wife, Egwina, was called a shepherd's daughter, and this is explained by the fact that in the court language of those days all non-military men, of whatever rank, were supposed to be engaged in the rearing of sheep, and called shepherds. The term "spinster," by which in Great Britain all unmarried women are designated, and the origin of which cannot be traced, proves that in early times spinning must have been the common employment of females.

About the middle of the tenth century the afterwards famous

woollen trade of Flanders took its rise; and to the artisans of that country England is indebted for much of that technical instruction which so greatly aided her in laying the foundations of her vast woollen industries. In the time of William the Conqueror, a number of those skilled Flemish workmen, being forced from their territory by an encroachment of the sea, came to England, where they made fine woollens. At first they were established about Carlisle, but afterwards Henry I., finding they did not agree with his other subjects, removed them to a district which now forms part of Pembrokeshire. For a long time after this there appears to have been a large commerce in wool and woollen goods between England and the Netherlands, the latter country maintaining its pre-eminence in the manufacture of cloth, and the former its reputation for the quality and quantity of its wool. In the beginning of the fourteenth century the woollen manufactures of the Netherlands were in such a prosperous state that in the city of Louvain alone there were no less than 4,000 master weavers and woollen drapers, and above 150,000 mechanics. The quantity of wool consumed must have been very large, and it was chiefly imported from England and Spain. At this time the state of the woollen trade in England had become very depressed, on account of the wars and troubles of several successive reigns; but shortly afterwards Edward III., who did a great deal to revive it, ascended the throne. At the beginning of his reign a Flemish clothworker, named John Kemp, settled at Kendal, where it is said, his name still appears. The cloth called "Kendal-green", afterwards became celebrated, and is mentioned by Shakespeare. By invitations and promises Edward persuaded seventy families of Walloons to come to England, who finally settled in Yorkshire, Gloucester, and the western counties, imparting by their skill new vitality to the cloth trade of their adopted country. A greater number of Walloons subsequently came to England from the Low Countries on account of the Duke of Alva's religious proscriptions in Queen Elizabeth's time.

We may here remark that some of the northern nations of Europe—notably Denmark, Norway, and Sweden—whose whole riches had previously consisted of furs, appear to have become very slowly accustomed to the use of woollen and other woven fabrics, and that chiefly through their piratical expeditions. Even as late as the twelfth century they plainly looked upon such textiles as objects of extravagant luxury; because we find that at that time the principal men at the Danish court were clothed in sheepskin, and that the Duke Canute excited the envy of the courtiers by wearing a red cloth dress.

British wool began to be exported about the close of the twelfth century, and after Henry III. permitted the importation of foreign woollen cloth, the export trade in wool remained for centuries the most lucrative which the country possessed. About the middle of the thirteenth century, wool-staplers, or persons who arrange the wool of a fleece into different qualities, are mentioned for the first time; and in 1275 we incidentally get a glimpse of the probable quantities of British wool sent abroad. All commerce between England and Flanders having ceased through a misunderstanding between the two countries, Edward I., on account of his exhausted treasury, allowed some Florentine merchants to export 1,068 sacs (281,952 lbs.) of wool, upon which they paid 10s. per sac of duty—that sum being equal to about £7 10s. in our day. This also shows the heavy restrictions then existing on commerce, which before long became oppressive, as Edward soon afterwards doubled the duty, and in 1286 increased it to 40s. per sac. The three years' famine which followed the dreadful epidemic of 1315 caused sumptuary laws to be passed for the regulation of the price of food. From these it appears that no one could demand more than 20d. for a fat sheep, and if shorn 14d., thus giving the value of the fleece as 6d., or 7s. 6d. of the present money.

It is worth noticing here that Edward III. seems to have been, more than any other contemporary sovereign, alive to the benefits accruing to a nation from foreign commerce. He always found, when his coffers were empty, that a tax on wool was the easiest way of raising money, and on one occasion he sent a large quantity of wool to Cologne to redeem Queen Philippa's crown, which had been pawned for £2,500. As showing what such a tax then yielded, it may be stated that in 1354, when the exports of wool had reached the large quantity of 8,356,864 lbs., the duty on it amounted to £277,606 2s. 9d., an enormous sum, if the difference in the value of money between then and now be considered. About this time the first mention of exported woollen cloths and also of worsted goods occurs. The difference between these two kinds of fabrics will be afterwards explained; but we may here notice the fact that the spinning of worsted yarn had now made considerable progress at Norwich, near which, at Worstead, this peculiar kind of woollen yarn was first made. Leeds, the present centre of our woollen industry, is mentioned for the first time in connection with this manufacture during the reign of Edward III. The notice occurs in a record in the Tower of London, and refers to fulling mills in the possession of a Thomas Burgers, which were rented at 33s. 4d. per annum.

At the close of the fourteenth century the superiority of Spanish wool over the English for broad cloths began to be understood, and afterwards, accordingly, the price of British wool progressively declined; although the *long wools* of the Romney Marsh, the Lincoln, and the Leicester breeds of sheep, continued to be superior to those of foreign growth. In 1470 the price of Spanish wool appears in a claim for damages on account of a quantity seized by an English privateer. It is there put down at 6d. per lb., while the best English wool at that time would hardly bring 2d. per lb.

By the absurd enactments of Henry VII., and the religious dissensions during the time of Henry VIII., the commercial interests of the country greatly suffered, so that during both reigns the wool trade was in a declining state. Yet in the reign of Henry VIII. there were some manufacturers celebrated for their wealth, and among them John Winchcombe, popularly known as Jack of Newbury, who kept 100 looms at constant work, and was able to send sixty soldiers to Flodden Field equipped at his own expense. It would seem that Winchcombe's kerseys were highly esteemed abroad, since in a letter addressed in 1549, by the English envoy at Antwerp, to Lord Protector Somerset, he says, in reference to the payment of a large debt to the Antwerp money-lenders, "it shall be best to have hither 1,000 of Winchcombe's kerseys." In this reign we find Leeds described by a writer named Leland, who says, "The town standeth most by clothing." We must not omit to state that in 1530 the spinning-wheel was invented by Jurgen of Brunswick. It would doubtless be more correct to say that at this date he introduced it into Europe, as it had existed from immemorial time in Eastern countries. Its introduction, however, did great service to the woollen manufactures of England.

Soon after the accession of Elizabeth, under whose wise and firm rule the manufactures of the country were singularly prosperous, the persecutions in the Netherlands by the Duke of Alva, emissary of Philip of Spain, drove about 5,000 refugees to England, who settled in Canterbury, Maidstone, Norwich, Colchester, and other towns. Many of these were the most experienced and ingenious manufacturers of woollen and silk textiles of their day. By their superior machinery and manipulative skill, especially in certain kinds of light fabrics, they contributed so much to extend the manufactures of this country, that in the year 1582 the exports of British cloth were nearly double what they had ever been before. In 1600 the East India Company was established, during whose *régime* a great trade grew up, in which the woollen manufactures had a not inconsiderable share.

In the reign of James I. the art of dyeing—well known to the English manufacturer four hundred years before—had become utterly lost. The white cloths made in England were accordingly sent to Holland to be dyed and dressed—a state of matters which was not only humiliating, but was also attended with heavy loss to this country. Sir Walter Raleigh states that the profits made by the Dutch on this branch of the woollen manufacture amounted to £400,000 per annum. Strenuous efforts were therefore made to recover the lost art, and in 1667 these were at length successful. In that year a dyer, named Bremer, came from the Netherlands with his workmen, and being well treated by the English government, he made the art of dyeing so well known in England, that our woollen manufacturers were soon, in that respect, independent of the Continent.

The woollen trade was in a depressed condition under the Stuarts, chiefly on account of vexatious restrictions and prohibitions, but partly also because the manufacture had now made great progress in other European States. Nor on account of various distractions were matters much better during the Commonwealth. In consequence of the revocation of the Edict

of Nantes by Louis XIV. in 1685, about 50,000 French Protestants took refuge in England. Many of these Frenchmen were highly skilled in some branches of the woollen and felt manufactures, previously but little known in England, so that like the Flemish refugees who came over a full century before them, these foreign workmen did a lasting service to British industry. Just after the revolution of 1688 the earliest perfectly reliable accounts of the woollen trade occur. Yorkshire then begins to figure as a cloth-making county; the first suggestion of a power-loom had recently been made, and the records of the Patent Office had then begun to give all manner of details about new machines, processes, and fabrics.

INDIAN RUBBER.—V.

BY GEORGE GLADSTONE, F.C.S.

PROPERTIES OF VULCANISED CAOUTCHOUC—HOW USED—PRINCIPAL APPLICATIONS.

THE special characteristics of the vulcanised as compared with the natural caoutchouc are as follow:—

1. *Influence of Temperature.*—The original article always becomes hard and loses its elasticity at about the freezing-point of water, so that it is inapplicable for many purposes where great cold is required, and is useless in such climates as those of Sweden and Northern Russia during the winter months. The frozen article recovers its elasticity on the application of heat, just as the threads already described, which have been stretched when hot and then allowed to cool, only regain their contractile power on being again warmed. No amount of cold appears to have any effect whatever upon the vulcanised rubber; neither does a thread of it, which has been stretched to the utmost, remain thus extended under any circumstances, but will always return to its original length on the tensile force being withdrawn. Turning to higher temperatures, while the native article becomes uncomfortably sticky in the heat of tropical climates, commences to melt at 248°, and if heated up to 398° will no longer return to the solid state on cooling, the vulcanised is in no degree affected by exposure to any temperature short of 300°, but becomes harder on the heat being still further raised.

2. *Adhesiveness.*—This, which in the original article is often a source of inconvenience, while at other times it is of very great advantage, is entirely lost under the process of vulcanisation. This circumstance frequently necessitates a considerable change in the process of manufacture.

3. *Impermeability to Water, etc.*—Both descriptions of material seem to be equally efficient in this respect.

4. *Insolubility in Acids, Alkalis, etc.*—In this particular the vulcanised far exceeds the ordinary rubber. It is true that any excess of sulphur which may exist in the converted article may be removed by those chemical reagents which will act upon the sulphur itself; but this is an advantage rather than otherwise, as such sulphur would cause an unpleasant odour, and in process of time be liable to effloresce upon the surface of the rubber, a probability which the manufacturer has always to guard against; but beyond this the greater part of the sulphur which it was found necessary to use in order to produce vulcanisation may be subsequently removed by chemical means without destroying the effect, so that not more than 1, or at most, 2 per cent. may remain. So completely, indeed, may the sulphur be removed, that it has been doubted whether this ingredient enters into chemical combination with the Indian rubber at all, and whether the vulcanised article should not be regarded as merely an allotropic condition of the other. Except in this respect the vulcanised product is equally insoluble in all the menstrua in which the original article is; but beyond this it is less soluble in the liquid hydrocarbons and other solvents of the native rubber; and, which is a matter of no small practical importance, the non-drying oils, grease, etc., do not affect it at all.

5. *Pliancy.*—In this respect the vulcanised article is undoubtedly superior, for while it loses nothing at the ordinary temperatures, it will be seen from what is said under the first head greatly to excel the raw product both at high and low temperatures.

6. *Elasticity.*—We now come to the most valuable characteristic of the native rubber, and it is something to say that this is not injured by vulcanisation. We may go further, and add that it is greatly improved by this process, provided that the temperature at which it is conducted be not too high. Its elastic power is a matter of such importance as to call for considerable detail. The extent to which it may be stretched, and the readiness with which it returns to its original dimensions on being let go, may be easily illustrated by a reference to the elastic bands which are now in such extensive use that almost every individual in the kingdom, whether high or low, must be familiar with them. Had the discovery been applicable to no other purpose than this, it would even then have been one of no trifling importance. The converse, its power of resisting pressure, and of returning to its former thickness on the compressive force being withdrawn, has been very thoroughly tested in the following manner, and with the result stated:—A block of the vulcanised article, of the kind used for the manufacture of railway-carriage springs, measuring 6 inches outside diameter, and 6 inches depth, with a hole through the centre of 1 inch diameter, was taken and put under a press. A pressure of $\frac{1}{2}$ ton reduced it to a depth of $5\frac{1}{16}$ inches; 1 ton to $5\frac{1}{16}$ inches; $1\frac{1}{2}$ tons to $4\frac{9}{16}$ inches; 2 tons to $4\frac{3}{16}$ inches; $2\frac{1}{2}$ tons to $3\frac{13}{16}$ inches; 3 tons to $3\frac{4}{16}$ inches; $3\frac{1}{2}$ tons to $3\frac{1}{16}$ inches; 4 tons to 3 inches. The block was left under pressure for forty-eight hours, and in each case returned to its original dimensions after a short period when the pressure was removed.

Such being the leading characteristics of the vulcanised caoutchouc, it will only remain to describe those processes of manufacture which differ from those of the native article, and to refer to some of the applications for which it is suited.

In making the vulcanised article a great variety of expedients have been adopted for producing further modifications, and all sorts of articles, such as lead, antimony, chalk, magnesia, phosphorus, etc., in some form or another, have been compounded with it. Some of these considerably add to the weight of the product, and some, perhaps, serve no other useful purpose beyond this, that they generally increase its solidity, though they diminish its elasticity. It may, therefore, be taken that the compound of caoutchouc with sulphur only, one cubic foot of which will weigh about 60 pounds, is the best article, and that any samples which exceed that weight are of inferior quality, though for certain special purposes they may be desirable. The compounds are so various that some samples will weigh more than half as much again as the figure above given; but the buyer of such should understand that part of the price he is paying is for so much mineral.

It must not be understood, however, that all these substances are deleterious. Magnesia imparts a softness to the surface which is generally agreeable; the sulphide of antimony is also used to make what is known as red rubber, which possesses good general qualities, especially as to its elasticity, while it is less liable to that measure of decomposition which more or less affects all Indian rubber and its compounds after years of exposure to the air, rendering it brittle and no longer elastic.

The process of making this kind of rubber is as follows:—The crude sulphide of antimony is finely pounded and then boiled in water with one of the alkaline carbonates, by which, and the addition of a slight excess of hydrochloric acid, it is converted into kermes mineral, the orange-coloured double sulphide. This is worked up with the Indian rubber in the masticator, and subjected to a temperature of about 280°.

In consequence of the loss of a very convenient property of the original substance—viz., its adhesiveness—the vulcanised goods are very frequently made of the common rubber, and then submitted to the action of the sulphur. Another plan which may also be adopted with advantage is to work in the sulphur along with any other ingredients that may be desired, such as the silicate of magnesia, or any colouring matter, during the process of mastication, taking care to keep the temperature sufficiently low to avoid vulcanisation; and then, after the articles intended have been manufactured from this compound, to submit them to a temperature of 280° or upwards.

The time required for effecting the change varies in proportion to the thickness of the mass. Thus, in the previous extract from Mr. Hancock's patent (Article IV.), ten minutes and upwards was spoken of for vulcanising a sheet of $\frac{1}{16}$ of an inch in thickness, according to whether the temperature employed was 370° or less; but the thin films which are sufficient to render a cloth waterproof can be thoroughly converted by exposure for one and a half to two minutes in a chamber heated

to 290° or 300°. For such articles as these a large stove or chamber heated by hot air, in which the goods can be freely extended, is the most convenient apparatus. Small articles may be rapidly converted at a higher temperature by passing hot irons or cylinders over them.

As to giving the reader a full detail of all the appliances of the vulcanised rubber, it would be simply bewildering. This may be sufficiently gathered from a study of the contents of the window of one of the many shops belonging to the principal manufacturers, and which are exclusively devoted to the sale of these goods. Besides these, however, there are many articles which do not generally appear in shop-windows.

Elastic bands and carriage springs have already been incidentally mentioned. The former belongs to a large class of small applications which administer to one's daily convenience, such as the washers in the lids of portable ink-stands, soft and indestructible toys for children, braided elastics for pocket-books, purses, umbrellas, wristbands, garters and braces, trouser-straps, sponge-bags, bungs, stoppers, ink erasers, balls, and a great variety of others not to be despised. Some of these are made of sheets cut either in the ordinary way or by stamping into the form required. Others are made in moulds, such articles being very commonly moulded prior to vulcanisation, and then converted by the agency of heat before being withdrawn from the moulds. The material is very frequently forced while warm into the mould by the application of considerable pressure; but sometimes when a hollow article is required it is deposited from a solution; in the latter case, after a certain thickness has been gained, the rest of the liquid is poured off and a fresh supply introduced, so as to add a second layer, and so on until the required thickness is gained. The moulds may be made of metal in one or more pieces, though glass is sometimes used with advantage. To prevent the rubber from adhering to the surface of the mould, it is usually dusted over first with finely ground silicate of magnesia. All kinds of devices may be cut into the surface of the mould, which will produce figures in relief upon the exterior of the articles made in them.

FARMING AND FARMING ECONOMY.

By Professor Wrightson, Royal Agricultural College, Cirencester.

XVIII.—SHEEP.

INTRODUCTORY REMARKS—LONG AND SHORT-WOOLLED SHEEP—COTSWOLDS—LINCOLNS—ROMNEY MARSH—LEICESTERS—BAMPTONS—SOUTH-DOWNS—HAMPSHIRES—SHROPSHIRES—OXFORDS—DORSETS—EXMOORS.

It is difficult to conclude as to the relative importance of cattle and sheep. Both are eminently useful to man, and each is fitted to fill its own peculiar place in our rural economy. Cattle occupy the best grazing land, and the clay land districts of the country; they also are reared in large numbers upon the moors and hills of the west and north. Sheep are found in every part of the country, but are peculiarly associated with light lands, and high mountain tracts, where cattle do not find a congenial home. In the present series we have treated of mixed husbandry, where arable land is carried on simultaneously with the rearing and fattening of live stock. It is, then, with the relations of sheep to arable farming that we have particularly to do, and in contrasting them with those of cattle under similar circumstances, we observe the following differences:—Cattle require housing in winter, while sheep will fatten readily out of doors in the most inclement seasons. Cattle require their "roots" to be carted from the field to the homestead, while sheep eat their swedes where they were grown. Cattle-feeding entails the use of straw as litter, and expensive haulage of the manure produced during the fattening stage to the field. Sheep require no litter, and their manure is spread exactly where it is wanted. Cattle require very constant attention, while sheep, although also requiring great care and supervision, are, on the whole, more independent. Cattle (except in the case of milch cows) yield only one commodity—beef; while sheep yield a constant supply of wool, as well as mutton. These considerations point out sheep as a more profitable stock than cattle, where the situation is congenial. Where land is light and dry, then all the advantage of feeding root and forage crops off the ground by means of sheep may be realised; but where land is stiff, the treading of sheep, instead of doing good, does harm. Under these latter circumstances, it is much the best plan, if roots are grown at all, to cart them off, and consume them by means of cattle in sheds, and such heavy lands are especially benefited by the farm-yard manure made by cattle. It is for these reasons that we find the cultivators of stiff lands leaning to cattle as the best media for changing their root-crop into money, while sheep husbandry, on the other hand, has become characteristic of light land tracts. It has been proposed to accommodate sheep to heavy soils by shed-feeding them instead of cattle, and this can be done with good results, provided the sheds are airy, and the sheep are not overburdened with wool.

In giving some account of sheep husbandry, we find in the first place that a large number of breeds divide the country among them. We shall, therefore, in the first place, and as briefly as possible, give the leading characters of the principal races, and then make some remarks upon the rearing and fattening of sheep. Sheep are commonly divided into long and short-woolled races, while others have been described as middle-woolled. This character of length of fleece is accompanied by traits which are worthy of attention. Thus, the long-woolled races are usually heavy in the carcase, suitable for low-lying and rich pastures, somewhat coarse by comparison in their mutton, long and heavy in their fleeces, white on the head and legs. Short-woolled sheep, on the other hand, are smaller and lighter in the carcase, well adapted for downs and sub-mountainous tracts, yield a very high quality of mutton, a short and fine wool, and are brown, or even black, on the face and legs. The principal long-woolled races are the Cotteswolds, Lincolns, Romney Marsh, Leicesters, and Bampton breeds. The short-woolled sheep are well represented by the Sussex and Hampshire Downs, the Shropshires, Dorsets, Exmoor, and numerous other Down races co-extensive with the chalk range. The Cheviot sheep may be mentioned as a middle-woolled race, exceedingly useful in the locality after which it is named, as well as for crossing purposes.

Cotteswold sheep are found in the greatest perfection upon the hills after which they are named. These form an elevated tract in Gloucestershire and Oxfordshire, and extend into Worcestershire and Somerset. The sheep, it is said, have conferred their name on the hills, rather than the hills on the sheep. In mediæval times the wolds were covered with "cotts," or sheds in which the sheep were housed in order to protect their wool from injury in inclement seasons—hence "Cotteswolds." These sheep have partaken of the general improvement in all kinds of live stock, and were in the earlier part of the century crossed with the New Leicesters. They are now improved by selection alone, and may be thus described. The Cotteswold sheep stands high on his legs, and carries a heavy carcase and a grand head. The face and legs are, as a rule, white, but spots of grey are not considered as indicative of impurity of race. The face is wedge-shaped, wide between the eyes, and black skin, where it shows at the nose and eyes. Pinkness of skin on the nose indicates delicacy in this breed as well as in Leicesters. The head is surmounted by a top-knot, or long lock of wool hanging over the eyes, and always looked for in a sheep of any pretensions to merit. The neck or scrag must be tapering from the shoulders to the head, be full and thick, and have a good crest; the shoulders must be level with the back, wide between the blades, smoothly laid and graduating easily into the neck, without abruptness or coarseness; the animal must be thick through the heart, from blade to blade; the bosom must be deep, wide, and prominent; the ribs well sprung; the back broad and level; the hips and rumps (quarters) well carried out to the tail, and level with the back and shoulders; the thighs well developed inside and out, giving good legs of mutton; the carcase deep, long, and wide; the legs well set on "at the four corners;" the hocks and knees strong, and the sheep upright on his pins; the fleece heavy, thickly set, and characterised by a rather bold and large curl. The Cotteswold is next to the improved Lincoln in size, and may be readily brought to twenty-five pounds per quarter at ten months old. The fleece, under ordinary circumstances, will weigh from eight to ten pounds, but extraordinary weights, rising to double those just given, are not uncommon in good flocks. High prices are given at the ram sales which are held annually on the hills. Above 200s. has been given, and averages of £25 to £26 have been realised. There is a considerable export trade, and during the last two or

three years a great impetus has been given to the breeding of rams by the increased colonial demand.

The *Lincoln sheep* has for long occupied the rich pastures of its native county. It, like the Cotteswolds, has been improved by the importation of Leicester blood in the proportion of about 1 to 3. The Lincoln is the largest and heaviest fleeced sheep we possess, and instances are on record of sheep having weighed eighty to ninety pounds per quarter. Captain Catlin, of Needham Hall, Lincolnshire, has furnished us with particulars of a Lincoln two-shear sheep, whose carcase weighed 27¼ pounds. A correspondent writes:—"I enclose two staples of the wool which I drew from two fleeces as they lay upon the winding board: by measuring you will find them 20½ inches in length, and you will remark how strong is each individual fibre, and how well the strength is maintained throughout. At my request, three of the fleeces were weighed; they were as follows:—No. 1, 20 pounds; No. 2, 18½ pounds; No. 3, 20½ pounds. I do not, of course, wish you to suppose that I chose any but the best I could lay my hand upon; but I have no hesitation in saying that there were many sheep in the pen that would clip as much or more wool." Mr. Kirkham, of Audley, writes in March, 1870, after a bad season:—"There is a considerable demand for Lincolnshire sheep for exportation to Australia and Buenos Ayres, and their worth seems to be gradually, although slowly, appreciated. This is not to be wondered at when a good Lincolnshire hog in his wool is worth £6, but to arrive at this result, they must be well cared for from the first."

The Lincoln, in many respects, closely resembles the Cotteswold sheep, but is furnished with a less prominent top-knot, and is straighter along the top, carrying the head somewhat lower. The wool is exceedingly long, and has a peculiar glistening appearance, which has earned for it the name of "lustre wool." This peculiarity is, however, restricted to sheep bred and kept in Lincolnshire.

The *Romney Marsh* form another tolerably distinct breed, although something of the "professional eye" is required to discriminate between them and the last-named race. They are a heavy-carcased, long-woolled, hornless, white-faced breed, with a considerable admixture of Leicester blood in their composition, and are well suited to the low-lying and rich pastures at the south of Kent, known as Romney Marsh.

The *Improved Leicester sheep* owed its origin to the care bestowed upon the original county breed by the celebrated Robert Bakewell, of Dishly, Loughborough, Leicestershire. This noted breeder brought out an improved race of cart-horses, the once celebrated long-horn cattle, and, lastly, the Leicester or Dishly sheep. The improvement was effected by selection alone, and under this system, rigidly carried out, the old breed was reduced in size and rendered more symmetrical, its fattening tendencies were greatly enhanced, and early maturity was encouraged. Whereas formerly sheep were fattened at three, or even four years old, under Bakewell's management they could at last be made ready for the butcher at from ten to fourteen months old. Very little is known of the plan pursued by Bakewell in making these improvements. He communicated his knowledge to few, and for long the best blood was retained by a clique known as the "Bakewell club." The Leicester sheep is less in size than either the Cotteswold or Lincoln. His wool is shorter and less abundant, his top-knot either entirely wanting, or scant, and the animal is characterised by greater compactness and firmness of touch than the preceding races. The Leicester has extended over the whole kingdom, and has been exported to all parts of the world. It possesses the useful property of retaining its characters under very varied conditions of soil and climate, and has been crossed with a large number of local breeds. Thus, in Scotland, the Cheviot and Leicester cross is highly esteemed; in the north of England the same sort of cross-bred sheep are very prevalent. In Durham and Yorkshire, "mules" bred between Leicesters and the Black Faced Mountain breed are justly popular as a hardy race, well suited for wintering upon grass land, and fattening the succeeding summer. In Lincolnshire we have already noticed the effect of the union between Leicesters and the Old Lincoln, and the Romney Marsh and Cotteswold sheep need not be further commented upon as good instances of the same policy. The Leicester has also been very successfully crossed with Sussex and other downs, and the result has been a large-framed, strong-constitutioned sheep, combining the advantages of plenty of wool and first-rate mutton.

As a pure breed the Leicester is probably not so much in demand as formerly, and it is rather the fashion to speak of it as having had its day. There is, however, so much of rivalry among the promoters of the various breeds of sheep, that ill-tempered remarks may often be attributed to this cause.

The *Bampton* breed is found in Devonshire and Somerset, and may be generally spoken of as a long-woolled, white-faced, hornless breed, suitable for rich valley pastures.

SHORT-WOOLLED SHEEP.

Foremost among these is the *Southdown* or *Sussex Down*, native to the chalk range which extends to the east and west of Brighton. It is the most beautiful race of sheep in the country, and when exhibited at our great shows, never fails to attract the admiration of the public. The modern Southdown owes its improvement to the Ellmans of Glynde, in the last and present century. Arthur Young, in his agricultural tour, noticed the improvement which had then been effected in the old Sussex sheep, and since that time great pains has been taken to further develop the breed by such men as the present Duke of Richmond, the late Lord Walsingham, the late Mr. Jonas Webb, Mr. Rigden of Hove, Mr. Phunix, and other well-known breeders. The Sussex down is of very symmetrical appearance, and the beauty of its form is the more apparent on account of the shortness of its fleece. The face and feet are fawn-coloured, and the head has much of the character of the fallow-deer; the eye is set in a not too prominent orbit, the crown is well covered with closely applied wool; the wool comes well forward upon the cheek, but it is not permitted between the eyes and nose; the "chap," or under jaw, is clean, or free from flesh; the fleece is short, and firm "as a board," showing cracks down to the skin when the animal turns. The remaining points relating to the general form of the carcase are similar to those looked for in other well-made sheep. The Southdown is a great favourite with butchers, as the mutton invariably pleases the consumer; accordingly a higher price by a halfpenny or penny per pound is given for these sheep. It is, however, not in high favour with tenant-farmers as a "rent-paying" sheep, but is more frequently in the hands of men of rank and fortune. It has been said to be essentially a "gentleman's sheep." The South-down loses some of its characters when bred for several generations away from the short, sweet pastures of the South Downs, and breeders have to go back to the hills for fresh blood, in order to maintain the standard of their flocks.

Hampshire Downs are a larger, coarser-looking, slightly longer-woolled race of sheep, with darker faces and legs than the last, and originated, according to Mr. E. P. Squary, in a cross between the old Wiltshire horned sheep and the old Berkshire knot with the South-downs, which were introduced into Wiltshire and Hampshire early in the present century.

From 1815 to 1835, the Hampshire Downs of North Hants and those of South Wilts were, owing to the different conception as to what constituted a good sheep, totally dissimilar in character. The Wiltshire sheep was larger, perhaps less handsome, and not so uniform with respect to colour as those of Hampshire, and an ewe with speckled face and ears was not necessarily draughted, provided she was possessed of other good points. To Mr. Humphry, of Oak Ash, near Newbury, is due, in a great measure, the present character and position of the Hampshire Down sheep. This agriculturist effected its improvement by careful crossing with the largest and best fleshed of the Babraham South-down flock. This means, applied with wonderful ability, and at a great cost, has at length resulted in the present perfect animal.

The *Shropshire* breed has of late come prominently into notice, and is doubtless the rising sheep of the day. Although now only improved by breeding *inter se*, these sheep originated by crossing the old Morfe sheep with South-downs, Leicesters, and Cotteswolds. The character of the Shropshire has not been so uniform as could have been wished, on account of the varying proportion in which long-woolled and short-woolled sheep had been used in bringing out certain strains of blood. Hence some flocks had a long-woolled, and others a short-woolled character. Latterly, the Shropshire judges have insisted upon a uniformly dark, or almost black face, with a firm "helmet"

of wool extending unbrokenly between the ears, and on to the forehead. No "grey" hairs are allowed in the wool, and these are looked for near the tail. The carcase is heavy and square, the legs short and widely set. Shropshire sheep are found in almost every county, and are extending rapidly in public favour.

The *Oxford Down* has many points in common with the Shropshire, and the uninitiated might find difficulty in distinguishing one from the other. One of the best points of difference is the top-knot, which in the Oxford down is composed of a long lock of wool, as in the Cotteswold sheep. The face of the Oxford has also a bolder expression, owing to its Roman form of nose, and is more usually mottled, while the best Shropshire type is uniformly dark. The Oxford Down originated in a cross between the Cotteswold ram and the Hampshire sheep.

The *Dorset* sheep is white-faced, horned, and short-woolled; the ewes are peculiar for dropping their lambs exceedingly early in the winter, and thus providing the London market with the earliest supplies of lamb.

The *Exmoor* sheep resembles in general appearance that last noticed, and furnishes mutton of very high quality.

TECHNICAL DRAWING.—LXXXVIII.

DRAWING FOR METAL-PLATE WORKERS.

In Fig. 640 the development of a square prism is brought under the notice of the student.

The mere development will, of course, be easily understood, since it is precisely the same as that of a cube, four of the faces being elongated instead of being square.

The object of the present lesson, however, is to show the section line on the development, thus enabling the workman to cut the metal out whilst flat, so that when bent, not only the general shape of the object may be formed, but the aperture caused by the section, and the covering of that aperture (which will be the true section), may be the result.

The section plane enters at the top, on the diagonal *a c*, and emerges at the angle *a′* of the bottom.

Draw the diagonal *a c* in the square *a b c d* representing the top of the present development.

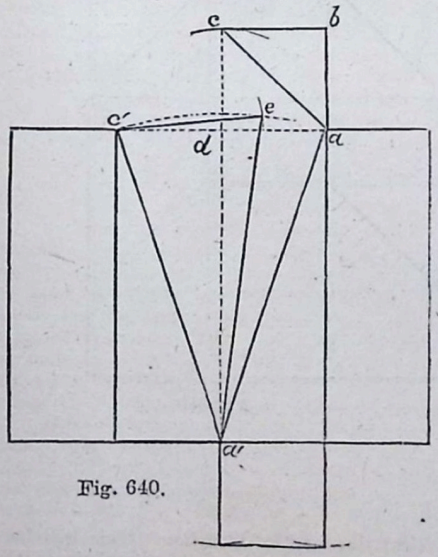


Fig. 640.

Now it will be clear that *a* is one of the points from which the section line is to be drawn, and also that when the development is folded into its proper form, *c′* would reach *c*; *c′* is thus another of the points of the section line, and *a′* will be the third.

Draw *a a′ c′*, which will be the line of section.

The covering for this aperture will then be an isosceles triangle, of which *a c* is the base, and *a a′* and *c′ a′* the sides.

In a material which may be bent, it may be economical to make the whole development in one piece, and therefore the present method is shown.

From *a′*, with radius *a′ c′*, describe an arc; and from *c′*, with radius *a c*, describe an arc cutting the previous arc in *e*.

Join *e a′*, *a′ c′*, and *c′ e*. Then the triangle *c′ e a′* is the required covering of the aperture.

Fig. 641 is another development of the same square prism, showing the section line caused by a plane passing from a line joining the middle points of two adjacent sides of the top to a similar line joining two opposite edges of the base. The method of procedure is as follows:—

Having drawn the general form of the development, draw the diagonal *a b*, and the line *c d* parallel to it, the points *c*, *d* being the points of bisection, or the middle, of the sides of the square.

Draw a corresponding line at the opposite angle of the square representing the other end of the prism—viz., *e f*.

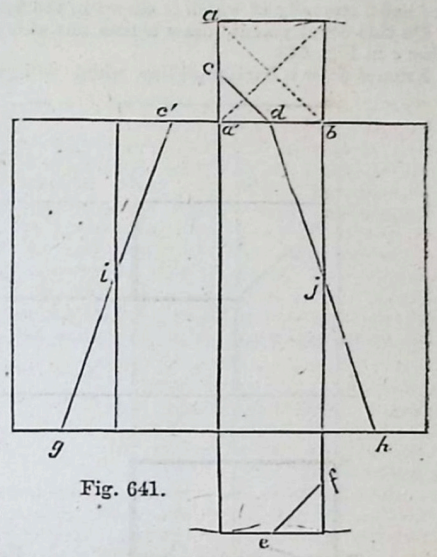


Fig. 641.

From *a′* set off *a′ c′* equal to *a′ d*—viz., the middle of the width of the face—and find the corresponding points *g*, *h* on the edges of the base.

Draw *c′ g* passing through *i*, the middle point of the perpendicular, and draw *d h* passing through *j*, and these will be the section lines.

Fig. 642 is the true section The width at top and bottom are of course equal to *c d*, and the width across the middle is equal to the diagonal of the square. To find the height, draw a side elevation of the prism, marking on it the section line, the length of which will be the height required.

Fig. 643, which has been given in an elementary manner in lessons in "Projection," and is here introduced in order that the further working out of the figures for the special use of metal-plate workers may be given, shows the plan and elevation of a piece of square metal piping, when the plane of the section passes from one side to the other at 45°: the section will thus be a rectangle, the length of which is equal to the section line, whilst the width corresponds with that of the side of the pipe.

Now, if when such a pipe has been cut through at 45°, the upper portion is turned round, rotating, as it were, on a pin fixed in the centre of the section, the two parts meeting on the line *c d* will form an elbow joint.

In the present example the joint forms a right angle, because the section line was made at 45° (that is, *half* a right angle); but an elbow of any angle may be formed by the same method, it being understood that the angle of the section line must always be half the angle required to be formed by the joint.

Fig. 644 is a projection of the object when placed at an angle to the vertical plane.

To draw this figure, place the plan at the required angle to the intersecting line, and draw perpendiculars from all its angles.

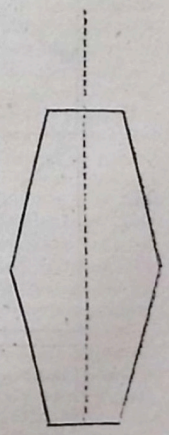


Fig. 642.

It has already been pointed out that when an object is rotated horizontally without its inclination being altered, its height is not altered. This may be frequently seen in the objects around us; for instance, a door, however much it may be moved on the line of the hinges, remains the same height; the uppermost extremity of a crane, when it is rotated so as to bring a cask or bale which has been raised from a vessel over the wagon waiting to receive it on shore, remains the same height, describing, in fact, as it moves round, a horizontal circle in the air.

Thus, then, this elbow joint, so rotated, is the same height as when its side was parallel to the vertical plane, as in Fig. 643. It is only necessary, therefore, to draw horizontals

from Fig. 643 to cut the perpendiculars drawn from the angles of Fig. 644 to complete the projection.

Fig. 645 is the development with the shape of the section attached.

Set out, in the first place, the four sides of the prism, with the ends, one only of which is shown in the figure.

On this development, draw across one side a horizontal line from *c* in Fig. 643.

From *d* draw a horizontal line, which will give the height of the right-hand face. Join these points by oblique lines, on one of which construct the rectangle representing the true section; and this would form the lid, if one of the parts were formed into a common coal-scuttle, as shown in Fig. 646.

In Fig. 645, it will be seen, there would be no waste of metal. The section line would so divide the plate that each portion would form a part of the pipe, the only difference being that in the part shown in fine lines, the joint will be one of the edges of the *back*, whilst in the other it will be in the *front*.

The method of obtaining the development and section line of a square pipe cut so as to form a double elbow will now be given in continuation of this study.

A B C D (Fig. 647) is the plan, and E F G H is the elevation of the pipe.

Draw I J and K L, the section lines as seen in the side elevation.

It will be clear that if the middle part, I J L K, were removed, the upper part, G H K L, could be brought down upon E F J I, and form a straight pipe as in the last lesson, and thus that the change is merely caused by rotating the middle piece, I J L K, as on a pin in the centre of each section, the upper and lower parts remaining vertical during the operation. This will be easily understood if a similar model be made of three pieces of wood.

When, therefore, this middle piece is rotated in the manner described, the lines M and N of Fig. 647 will take the positions of M′ and N′ in Fig. 648, whilst the lower portion, E′ F′ J′ I′, will occupy precisely the same position as in Fig. 647, as will also the upper part K′ L′ G′ H′, excepting that it is moved towards the right side and lowered.

Fig. 649 is the development showing the section line, which being constructed in precisely the same method as Fig. 645, will not require any further explanation.

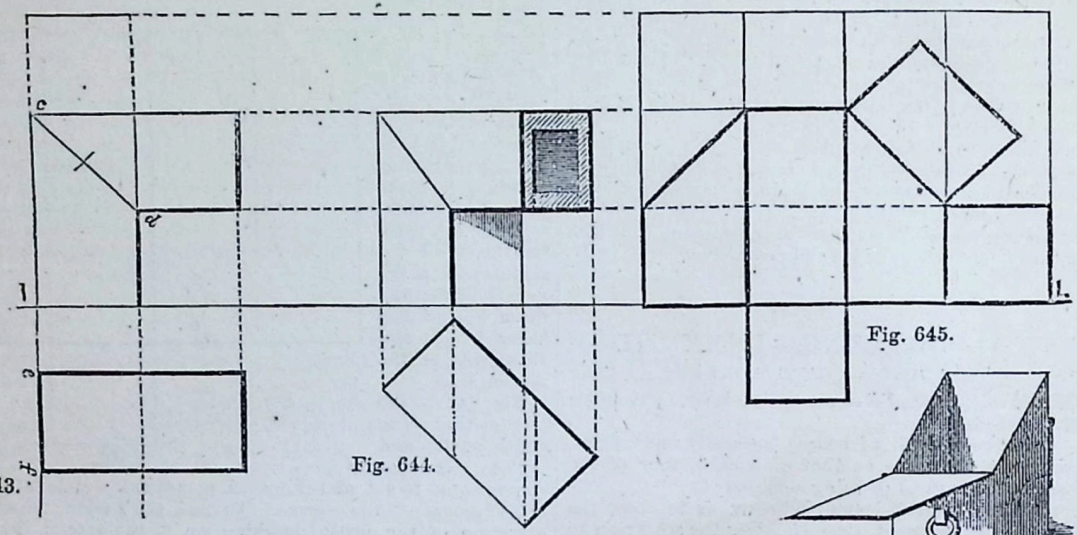


Fig. 643. Fig. 644. Fig. 645.

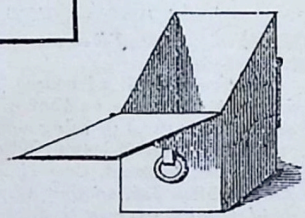


Fig. 646.

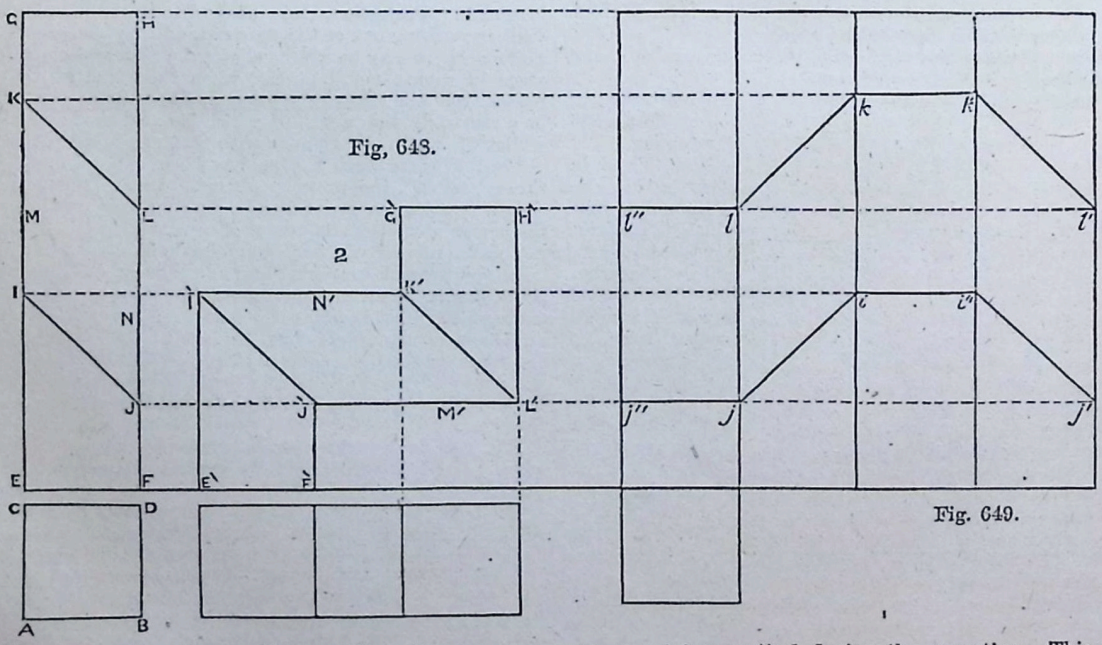


Fig. 647. Fig, 648. Fig. 649.

ENGLISH CARRIAGE-BUILDING.—V.

BY A LONDON COACH-BUILDER.

LINING AND TRIMMING (*continued*).

We may with advantage say a word to our carriage lace-makers, who seem to have made but scant use of the Schools of Design, for the improvement of their taste in producing new and suitable patterns in the manufacture of their goods. For a long period we had nothing but the old scroll or flower pattern, which was handed down from father to son as if by a fixed law. At length, when it was felt that some change was required, the absence of all taste in design was shown in the production of entirely plain worked laces, which deprived carriage linings of their chief element of lightness and beauty. Thanks, however, to the taste and discernment of Messrs. Whittingham and Walker, who perhaps have devoted more attention to this branch of industry than any other house in London, the trade was relieved from the necessity of either adhering to the old pattern or of adopting the opposite extreme. They introduced small neat designs in laces, eminently adapted to the purpose, and in 1857 they registered a pattern now extensively known as the double diamond pattern, which has not only become general in England, but is largely patronised throughout Europe and America. This and kindred patterns exactly fulfil modern requirements, and give us the necessary relief without extreme.

But with materials well and tastefully selected, the trimmer has still his work to do. The lining of a carriage is divided into many different parts, all of which have to be designed. Canvas or paper patterns have to be cut to these and properly fitted, before the material is touched with which the carriage is to be lined. Wherever superiority of workmanship is to be shown in this department, the French method of trimming is adopted as being more elegant than the English: we shall, therefore, confine our observations to this method.

In adopting the French method, silk is mostly used in the place of morocco, and its peculiarities consist in the manner of quilting. The different squabs are made up in horizontal pipes or flutes, which are tufted in different ways. To proceed, cut a pattern of strong paper the size and shape of the space to be trimmed, and draw on it with pencil the pipes, also mark the position of the tufts. On large pieces mark only one half, the other half being the same. The pipes of the back are usually twelve inches high, and from three to five inches wide.

The position of the tufts is considerably varied. Next stretch a piece of strong muslin in the stuffing-frame, lay the proper pattern on it, and mark the place of the tufts with a round awl. Mark the lines of the pipes on the muslin with pencil or red chalk. In the same manner the pattern must be transferred upon the inside of the material used for covering, making, of course, due allowance for the depth of the pipes. About three inches is a fair average for fulness at top, one inch for the height of the pipes, and an inch and a half for the width. For the last pipe an extra allowance is made in a narrow strip sewed on to it.

Next lay a quantity of hair on the frame, and form with it the swell desired. Keep the hair in position with a few long stitches, and lay the silk over it. Commence tufting in the middle of the lower row of pipes, and continue equally to both sides. Silk cords stretched into the channels between the pipes were at one time considered elegant, but their main merit was that they aided materially in preserving the original shape of the pipes. Backs are usually made couch-shaped, with a roll all round on the top, which at the same time form the elbow-pieces on the sides. In elegant carriages this roll is often elaborately executed in a screw-like shape, and continued from the door-pillar down to the seat-frame, being made by winding silk cords around the roll. These silk cords appear as a single thread, but in reality there are three different cords, which are wound at even distances. A style of trimming much used of late, both in France and Germany for low backs, is a row of pipes at the lower end, which are pinched to points at the top, and above these are three rows of regular squares. Squares are preferred to diamonds, as they are softer.

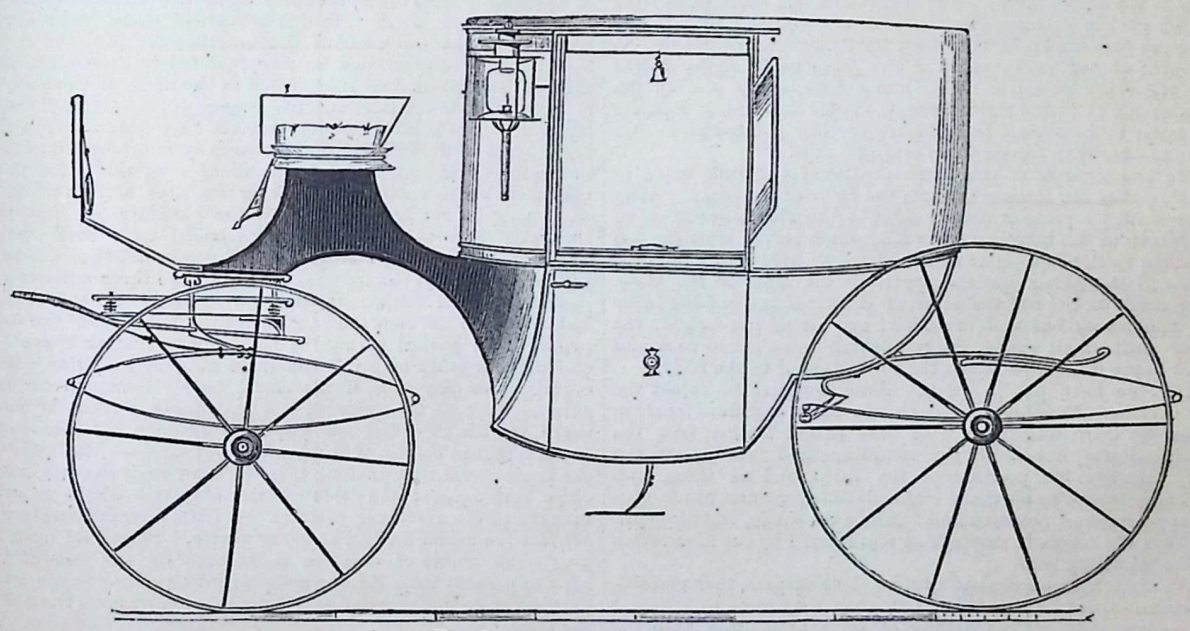


Fig. 9.—THE DOUBLE BROUGHAM.

Usually the back is laid on spiral springs, which are fastened as follows:—The back of the body is covered with coarse muslin, after being slightly stuffed, and on this muslin four rows of seven small springs each are set. For the lowest row, springs a little stronger may be used than for the other row. The highest row is set about an inch and a half below the edge of the back board, and the lowest row at six inches above the seat-frame. The springs having been sewn on with a bent needle, are tied first from right to left, and then from top to bottom. A thin cord will answer for this purpose.

The cord is first cut in lengths, and when the tying begins and at the end about six inches of cord are allowed. The cord is wound about the third ring of the first and last spring in each row, and afterwards the first ring is brought into the right position with the piece of cord allowed over. This will make the spring stand upright, and it can be raised or lowered on one side. The springs being thus all placed in position, they are finally tied cross-ways.

The squab, in this instance, is worked on coarse muslin, or

canvas stiffened with a little thin paste. It is set in the frame, and marked as we have described above. When the cushions press against the back and side pieces, frequently no stuffing is made, but simply a piece of fine linen is sewed reverse to the main piece, and this is called the "false finish." In fine work the stuffing extends clear to the seat-frame.

Of course each of these variations requires a different calculation for the muslin at the back as well as for the cover. For the latter an allowance of an inch and a half is made for the pipes from the lower to the upper end, and also for the points an addition of three-quarters of an inch. For each square in the height an inch and a half has to be calculated. The folds of squares, when laid over springs, being diagonal, easily draw apart when stretched out, while the folds of diamonds running up and down may be drawn tighter to a certain degree of stretching.

For the upper row of squares we have to allow for the backs at least double what we have to allow for the other rows—namely, three inches. For the width of every pipe an addition of an inch and a half is calculated.

Both cover and muslin being thus marked, we commence to draw in the tufts; every point marked on the cover has to lay exactly on the corresponding one of the muslin. The lowest tufts are first drawn in, then turn the frame and commence on one side at top, every point of the pipes being singly stuffed and the folds adjusted. This being done, every row of the squares can be tufted right through, stuffed and folded. Squares are easier to be worked than diamonds; but pointed pipes give more trouble than the ordinary straight ones.

The elbow-pieces of this finish consist of two rolls made of muslin; they are thinner towards the front of the seats. After being stuffed, a piece of muslin eight inches wide is sewed on all the length to the bottom of the roll, which serves after the roll is tacked to the door-pillar and the back to give it the required sweep in stretching and tacking it to the sides of the body. Then mark on the roll the width of the pipes and cut the cover for it, allowing one inch of width; and as to the height, the cover must go all round, the roll having to be sewed back and front to the linen with which the roll is tacked to the body.

After we have put in all the lining we have to adjust the silk curtains, the blinds and glasses to doors and front part, to cover the iron dash-frame with best patent leather, trim the coach box-seat, put on all the mouldings and beadings to the body, arrange the position of the lamps and fix them, and generally attend to all those little finishing points which give an appearance of neatness and finish to the whole, and at length we have the complete carriage as represented by our illustration in the preceding page.

We often hear purchasers express their surprise that pleasure carriages should be so costly; but when they come to acquaint themselves with all the details of their production, with the heavy investment of capital in the first instance by the manufacturer, the expensive nature of the materials used, the time, care, anxiety, trouble, and experience, together with sound practical knowledge involved, we think their surprise will considerably diminish; we think, moreover, they will see the necessity, in their own interests, of avoiding cheapness in such adjuncts to their establishments, and of placing themselves, in such matters, in the hands of builders of acknowledged reputation. For ourselves, we can confidently say, as the result of long experience, that nothing is more costly than an ill-built carriage, and its costliness is a continual source of annoyance and irritation to its owner, whereas the first outlay on an equipage well and soundly constructed, and elegantly finished, brings to the purchaser a constant feeling of pleasure, security, and comfort.

GREAT MANUFACTURES OF LITTLE THINGS.—XII.

LOCKS (*continued from Page 287, Vol. III.**).

BY CHARLES HIBBS.

BRAMAH introduced his celebrated lock with an essay, entitled, "A Dissertation on the Construction of Locks, containing, first, reasons and observations, demonstrating all locks which depend upon fixed wards to be erroneous in principle, and defective in point of security; secondly, a specification of a lock constructed on a new and infallible principle, which, possessing all the properties essential to security, will prevent the ruinous consequences of house robberies, and be a certain protection against thieves of all descriptions." This performance has long been out of print, but it has been quoted from in every subsequent work upon lock-making that is worth reading. The principle of his new lock was illustrated by a diagram, showing how the parts were made to lock into each other, a matter which we must endeavour to make clear by a written explanation.

The reader can, if he pleases, construct a model for himself with very little trouble. Take a common cardboard box, of the sort that jewellers use, and cut in each end a small perpendicular slit from the bottom upwards to a little more than half the height. In this insert a slip of cardboard long enough to project beyond the ends of the box, so that it can be worked backwards and forwards with the fingers. We will call this the bolt of the lock, and so far there is nothing to impede its motion. Cut now other slits in the *sides* of the box from the top downwards, to a little more than half the depth. They must be opposite to each other, and may be of any convenient number, say three on a side. In line with these three nicks must be made in the top edge of the longitudinal slip. If three shorter pieces of cardboard be now inserted in these slits, and pressed down until their edges catch in the nicks of the bolt, it is clear that the latter will no longer work backwards and forwards. But if corresponding notches have been made in the lower edges of the transverse slips, these when brought together in the line of motion of the longitudinal slip, will allow it to pass as freely as before. In making the slits and notches, a piece must be cut out neatly with the penknife, so that the slips may have some play, and the model may work easily. The cross pieces being now drawn backwards a little, the bolt will be locked, and cannot be moved until the three notches are pushed into line again. If they are drawn back to varying distances, and the ends then trimmed to a level, each one will require to be pushed forward a longer or a shorter space accordingly, in order to bring the three notches into line. The experimenter may now, if his model be rigid enough for the purpose, proceed to construct a key. Another piece of cardboard, the length of the box, may have its edge cut into steps so regulated in height, that when pressed against the ends of the cross pieces, and pushing them forward until the two outer steps rest against the side of the box, the whole may be brought to the unlocking position. A little further trouble will convert the model into an amusing puzzle. Place a lid upon it, glue small pieces of wood or pasteboard on the ends of the slips to prevent their being wholly withdrawn, and propose the problem of finding out the unlocking position without the aid of the key.

Bramah's cylindrical lock, with its little pipe-stem key, bears no outward resemblance to what we have described, but the principle of its mechanism is precisely the same. Only we must now abandon the fiction, convenient for the moment, of calling the longitudinal piece the *bolt*. In the real lock it would be called the *locking-plate*, and its form, instead of being an oblong square, would be that of a circular disc with a hole in the middle. The notches would be cut in the edge of the inner ring. Imagine one of these made of hardened steel, and cut in two halves across the centre. The barrel of the lock, turned and bored out of solid metal, has a deep groove cut round it, in which the edges of the locking-plate are inserted, and the two halves brought together. The plate being now securely bolted down, by pins passing through short pillars, to the case of the lock, the barrel will turn round upon it freely. But this barrel is composed of several parts, and the function of some of them is to prevent its turning round, as we shall see. First, there is the cylinder itself, a massive block of metal, with a hole drilled through the centre. A strong plate is screwed to the bottom, and on this plate has been turned an upright steel peg, which comes up through the hole in the cylinder, and forms the pin for the key. Radiating from this a number of deep slits are cut into the substance of the cylinder from end to end, far enough to reach and overpass the edge of the locking-plate, which lies in its circular groove. In these slits are inserted little pieces of steel, called sliders, which, filling the notches in the locking-plate as they are pushed down, effectually prevent

* This paper, having been mislaid, is now presented out of its proper turn.

the cylinder from turning round. The reader will readily conceive that the slides are also notched on their outer edges, and that at eccentric distances, so that they require to be moved forward to a greater or lesser degree to come to the unlocking position, like the slips in the cardboard box. When the lock is at rest, the ends of the slides are pressed up towards the keyhole by a helical spring which is coiled round the central pin, and which acts upon steps or shoulders cut in the sliders for that purpose. The key has a larger pipe than ordinary, and scarcely any bitt or projection. Round the end of the pipe are cut slots of varying depths, in which the ends of the sliders fit as the key is inserted in the keyhole, and which, pressing each down to the exact point necessary, bring the whole of the notches into the circular plane of the locking-plate, and enable the barrel to be turned round upon its axis by the pressure of the tiny stud on the side of the key. To increase the difficulty of picking, false notches are made in the sliders as well as the true ones, which alone are cut deep enough to allow of passing the plate.

It remains to be explained how the turning of the cylinder effects the passage of the bolt, which is an entirely independent limb. At the back of the base-plate which is secured to the cylinder is a small stud, which works into a curiously-shaped cavity in the hinder part of the bolt, so contrived that though the traverse of the stud will move the bolt backwards and forwards, no pressure applied to the end of the bolt will cause the cylinder to revolve. Usually, in applying locks of this construction to the doors of a safe, the massive bolts which secure them are not acted upon directly by the key, but are moved by a handle, and the office of the lock is simply to secure them in their position when the doors are fastened.

Such was the lock upon which Mr. Hobbs exercised his remarkable ingenuity in the July and August of 1851. In the window of Messrs. Bramah's shop in Piccadilly had been hanging for nearly half a century a padlock of their ordinary make, to which was appended a painted board, offering a reward of two hundred guineas to any one who should succeed in making an instrument that would pick or open it. The exact size of this memorable lock was as follows:—Width, 4 inches; thickness, 1¼ inch; over the boss, 2¾ inches. The cylinder was 2¼ inches in length by 1½ inch in diameter. Negotiations were opened in proper form, and an agreement was drawn up, binding both parties to the following conditions:—The lock was to be enclosed between two pieces of wood, and secured to a wall in such a position that only the keyhole and the hasp were accessible. The true key was to be sealed up, and not used until the operator had either picked the lock or abandoned his enterprise. An iron band, sealed by himself, was to cover the keyhole when he was not at work. Thirty days were allotted him for the performance of his task, and three gentlemen of eminence in the scientific world—viz., Mr. George Rennie, Professor Cowper, and Dr. Black—were appointed to act as arbitrators between the parties. All these preliminaries being adjusted, the lock was removed from the window to an upper room of the establishment, and Mr. Hobbs commenced his operations on the 24th of July. Some little misunderstanding as to the terms of the agreement, which rendered necessary an appeal to the arbitrators, caused a suspension of the work for some days, but on the 23rd of August Mr. Hobbs showed the lock with the hasp raised, and shot the bolt backwards and forwards in the presence of Dr. Black and Professor Cowper. The true key, being afterwards applied, was found to work as usual, which proved that the works had not been injured, and the lock had been truly picked. The time actually occupied was spread over sixteen days, and Mr. Hobbs was in the room with the lock exactly fifty-one hours. It is fair to say that Messrs. Bramah, though, honourably submitting to the award of the arbitrators, and paying the money, did so under protest, on the ground that the spirit of the challenge had not been fairly complied with; but it is not our business here to recount all the historical circumstances of the affair. Suffice it to say, that the event proved as much the excellence of the lock as it did the ingenuity of the picker.

Let us now endeavour to comprehend the methods adopted by Mr. Hobbs in the performance of this difficult feat. His first care was to relieve the pressure of the helical spring, which, as we have explained, is continually forcing the ends of the sliders towards the keyhole. On the top of this spring is fastened a small plate or cap, of circular shape, which fits under the shoulders of the sliders, and enables the one spring to do duty for all. Mr. Hobbs made an instrument that would effect his purpose out of a piece of thin metal tubing that would just fit upon the central key-pin, filing the end into teeth that would pass between the sliders. With this he pressed upon the cap, and pushed down the spring as far as it would go. To keep it there he fixed a curved iron stanchion on the woodwork in which the lock was embedded, in such a position as to overhang the keyhole, and by means of a thumb-screw passing through it, held his instrument firmly in its place. A lever of very simple construction, with a bent end, enabled him to exert such a continuous pressure upon the barrel in the direction tending to unlock it, as would answer his purpose, and thus he was free to act upon the sliders. Of these there were no less than eighteen, and each had, besides the true notch, two or three false notches, sufficiently deep to allow of that play in the interior which would deceive the most delicate manipulator. Mr. Hobbs used no more elaborate an instrument than a common steel needle to push down the sliders, while a fine crochet hook was employed to pull them back. Having first ascertained which of the sliders was most bound by the pressure tending to rotate the cylinder, he pushed it very gently until he felt it very slightly relieved, by which he knew that the locking-plate was either in the true notch or in one of the false ones. That done, he felt round cautiously for the next tightest, and effected the same process with that, and so on with them all. We may conceive how exceedingly nice must be the sense of touch that would enable him to do this, when we remember the extreme minuteness of the parts, and their number, compared with those in the Chubb lock, which had so easily succumbed to the tentative process in the hands of the same operator. The Bramah lock, too, from its construction, admits of much greater exactness in the fitting of the several parts than the best form of lever lock; and this, be it remembered, was a test lock, made for the purpose of challenge by their most skilful workman, and certain not to contain any accidental defects. It will readily be imagined, therefore, that it was the patient work of days to relieve the sliders one after another, and having done that, to ascertain which of them had only got the false notches into position, the cylinder being still locked by them, and unable to revolve. It must also be remembered that Mr. Hobbs had to remove his instruments and leave the lock intact at the end of each day, the keyhole closed with a sealed iron band. He had thus to begin each morning's operations by adjusting all the parts to the position he had gained the day before, a work of considerable time. To facilitate this he took accurate measurements upon a fine strip of brass of the exact position of the sliders when he had succeeded in relieving them, and recording these measurements in a systematic manner, he had data upon which to proceed. At the end of the fifth day, according to Mr. Hobbs's own account, the cylinder gave to the pressure exerted upon it by the lever, and began slowly to revolve, showing that the true notches had all been got into position; but at the very moment of triumph some part of the apparatus—whether the lever or the toothed instrument that was pressing down the spring, does not clearly appear—was found to be too weak for its work, and the attempt had to be abandoned for that time. A stronger instrument was made and applied; the tentative process was carefully repeated, and the lock at length yielded to the siege.

It cannot be said that the result of this trial was calculated to weaken the reliance of the public on the safety of the Bramah lock. Under the most favourable circumstances, and conditions partly proposed by himself, a man singularly gifted for the purpose, possessing an intimate scientific knowledge of lock construction, and the most consummate artist in his line in the world, had succeeded in opening a lock after working at it, undisturbed and in secret, for several days. No burglar would ever have such a chance, nor is it easy to conceive any combination of circumstances that would give any fraudulent operator such a chance in ordinary life. One of the precautions taken by the Messrs. Bramah—that of embedding the lock between two blocks of wood—was really, as we have seen, an assistance to their antagonist, as it gave him the opportunity of fixing his iron stanchion, which he could not have done upon a safe-door; besides which, he got all the advantages of perfect rigidity, a matter of great importance in the extreme delicacy of his operations. The reward was technically, and no doubt

fairly, won, but the reputation of the lock was not sensibly damaged.

The honour of being the first to baffle the skill of this hitherto invincible lock-violator belongs to Cotterill, of Birmingham. His lock is a modification of the Bramah, the parts being differently placed, so as to offer greater obstacles to fraudulent manipulation, and having one or two additional safeguards, which no art has yet been able to overcome. The body of the lock, instead of being an upright cylinder or barrel, consists of a flat circular plate of some solidity, in which grooves are cut, radiating from the centre like the spokes of a wheel. In these grooves lie the sliders, at right angles to the action of the key, instead of being perpendicular to it. Each has its own little helical spring pressing it toward the centre, and the key being notched, not on the end, but in a sloping direction, to varying depths, on the side, pushes the sliders outwardly when pressed down. The locking-plate is a vertical rim of steel, coming up through the solid plate a little above the depth of the grooves in a circular channel cut near its outside edge. This rim, being notched to receive the sliders, allows them freely to traverse in a longitudinal direction; but being itself securely bolted to the outside case, does not permit the solid plate, with its system of sliders, to revolve until the notches which are on the under side of the sliders come all into correspondence with it. A cap covers all, and the general appearance is neat and workmanlike. Of course there are false notches to increase the difficulty of picking, as in all locks of the kind made since the tentative process became known. The inventor claims for his key an advantage which no other key possesses—viz., that it is impossible to take an impression from it, owing to its peculiar formation. He also states that by his method of manufacture he is enabled to ensure that among many millions of keys, no two shall be alike.

Mr. Hobbs attempted to pick this lock in 1854, being challenged to the trial by Mr. Cotterill, who had been aggrieved by some expression respecting his patent used by Mr. Hobbs in a paper read before the Society of Arts. In vain the American replied that he came to this country as a competitor at the Great Exhibition, and that he must not be supposed to be open to any challenge that was backed by a pecuniary inducement. Mr. Cotterill persisted, feeling that the reputation of his lock was at stake, and the trial at length came off at Manchester. The lock was one which had been sold in the ordinary course of business, not made for test purposes, and it had been some months in use in the office of a consulting engineer. The operator was allowed to take measurements of the keyhole, etc., and to construct an instrument in his own time, before the actual test began. At length, when all preliminaries were adjusted, Mr. Hobbs sat down before the lock, and proceeded to push back the slides.

The instrument he used was described in a newspaper account of the time as the most ingenious picklock ever seen. It had twelve radiating needles or wires, that being the number of the sliders in the lock, and each had a screw adjustment which enabled him to propel it forward to the requisite extent. He had undertaken to open the lock within twenty-four consecutive hours, and at the end of half that time he announced that he had got ten of the twelve sliders into position. This turned out to be an error, and the examination of the lock which took place after the trial convinced him that he had really made no progress at all. However, he was unable, with the utmost skill and patience, to push his success further than the point he supposed himself to have gained; and a few minutes before the expiration of the time, he quietly rose and said, "The lock's yours; I give it up." When the interior was revealed, Mr. Hobbs was forcibly struck with the ingenuity of the mechanism that had baffled him, and candidly owned that he was just as near picking it when he first put the instrument in as he was at the last moment. "A man," he said, "might work at it a lifetime, and not overcome it."

The feature which had proved impregnable was one of the additional safeguards of which we have spoken, and consisted of an exterior ring of steel, encircling the whole mechanism, and offering the resistance of a wall to the passage of the sliders outwards on their way to the unlocking position. Their ends struck this wall just before their notches got into the magic circle of the locking rim. It would appear, therefore, that the lock could not be opened at all; but this outer ring was perforated to admit the ends of the sliders, and would allow them to pass, provided the perforations were brought opposite to the grooves in which the sliders lay. When the lock was at rest they were not exactly opposite, but each overhung a little the nose of the slider, so as to oppose some part of the solid rim to its perfect passage. The nose of the slider was bevelled so that it would force itself in if it got sufficient entrance, and adequate force was applied; the rim moving slowly round to accommodate it against the pressure of a spring which tended to retain it in its normal position. But the peculiarity was that the perforations were so regulated as to position, overhanging the sliders by different degrees, according as these impinged upon the rim sooner or later, that it required the simultaneous movement of them all to effect the pressure requisite to move the rim. Mr. Hobbs's delicate manœuvres were no match for this! Had he been fortunate enough to have selected by haphazard that slider which in its passage first entered the rim, and tried the tentative process upon it as a commencement of his work, the force he must have exerted to get it into position when unaided by the others would have effectually marred his sensitive touch. "Really," said he, on inspecting it after the trial, "it is a very ingenious and pretty arrangement, and reflects great credit upon Mr. Cotterill."

We have now carried our inquiry as far as is useful, considering the purpose with which we set out. Very many locks are in the market, other than those we have described, which deserve commendation for their ingenuity, but the cursory notice we could afford them would make the conclusion of this paper a mere catalogue. If the reader has been tempted into an interest in the subject by these necessarily brief descriptions of the three distinctive classes of locks—warded, lever, and slide, which embrace an infinite variety of modifications—he will be well rewarded by studying Tomlinson's "Rudimentary Essay on Locks," or the larger treatise on "Locks and Keys," by George Price, from both of which valuable assistance has been derived in compiling these papers.

TECHNICAL DRAWING.—LXXXIX.

DRAWING FOR METAL-PLATE WORKERS.

The principles shown in the two preceding lessons are further developed in the present one. Here Fig. 650 is the plan and elevation of a hexagonal prism, to be cut off at an angle of 45 degrees.

The method of projecting the elevation from the plan will not require any explanation in this place, and we therefore at once proceed to show the method of obtaining the true form of the section.

Let A B be the section line cutting the edges of the prism in C D.

It will be clear that A B in the elevation is represented by *a b* in the plan, and that C and D represent not only the two points so lettered, but two lying immediately behind them; thus, C D in the elevation corresponds with *c d* in the plan, and it will be seen that *c'* and *d'* lie directly at the back of these.

Thus, then, whilst the length of the section will be equal to A B, its width will be *c c'* or *d d'*.

These points being clearly understood by the student, the execution becomes easy.

From A and B draw lines at right angles to A B, and draw A' B' parallel to A B. Now from C and D draw lines at right angles to A B, cutting A' B' in 1 and 2.

On these lines set off from 1 and 2 the widths corresponding with *c* 3 *c'* or *d* 4 *d'* in the plan—viz., *e* 1 *f* and *g* 2 *h*.

Join A' *g e* B' *f h* A', and the figure thus completed will be the true section.

It will be evident that if the upper part of the prism were rotated on the lower, the two parts would form an elbow as already shown.

Fig. 651.—In this figure the prism is represented as rotated on its axis, so that one edge faces the spectator, whilst in Fig. 650 the side *c d* was parallel to the vertical plane of projection.

Horizontal lines drawn from A, B, C, D will give the view of the section in this figure; but it must be understood that this is not the *true* section, the form being apparently shorter, owing to the position of the section, which, of course, slants backward from the lower point.

Fig. 652 is the development of the prism, and on this the section line is shown. This is, as before, obtained by drawing horizontal lines from the points A, B, C, D in the elevation, to cut corresponding perpendiculars in the development.

The parts thus produced will, when folded into shape, be exactly equal.

The lessons thus given will, it is hoped, be sufficient to enable the student to adapt the system to prisms of any number of sides, and we therefore proceed to illustrate the system of developing the covering of pyramids. For the method adapted for triangular and square pyramids the student is referred to Lesson V. in "Projection," Vol. I., page 84. The information there given will serve as introductory to the following lesson.

Fig. 653.—A B C D E F is the plan and Fig. 654 is the elevation of a hexagonal pyramid, placed so that one of the edges faces the spectator, two of the sides of the base (B C and E F) being at right angles to the vertical plane of projection.

Fig. 654 is cut by a line parallel to the base, and it is required to find the true section of the pyramid when cut by a plane of which the line G H is the elevation.

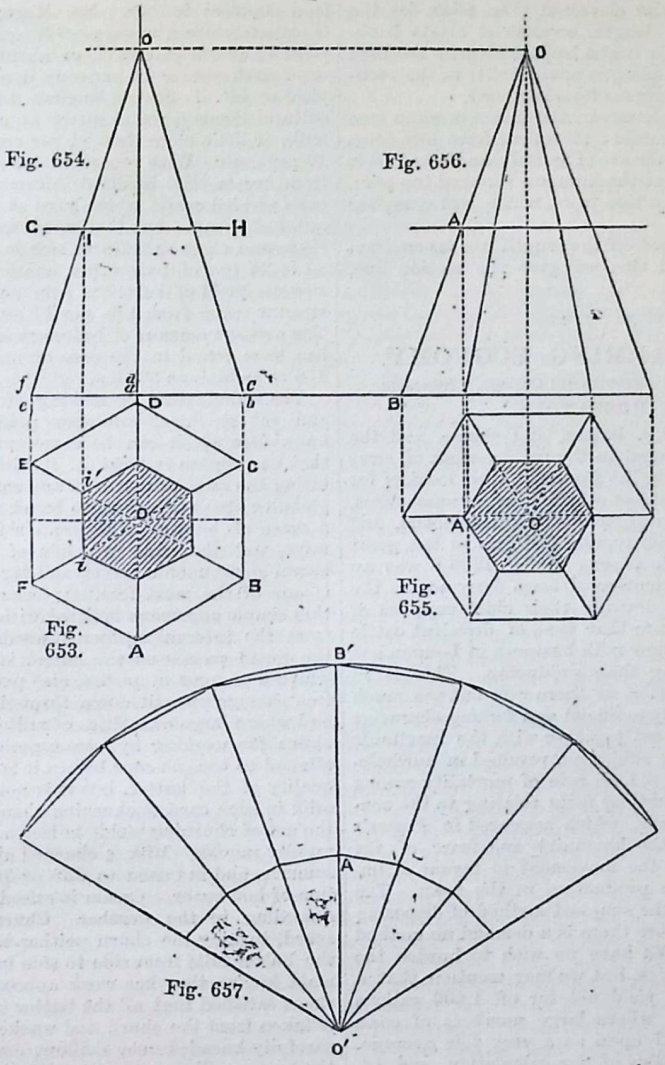
Now it will be clear that in this position each of the lines in the elevation represents two edges rising from points similarly lettered in the plan, since in the plan the three distant angles of the hexagon are immediately behind the other three, and thus the lines *b c* O and *f e* O in the elevation represent not only two edges each, but the triangular side of the hexagonal pyramid contained between them—viz., B O C and F O E in the plan.

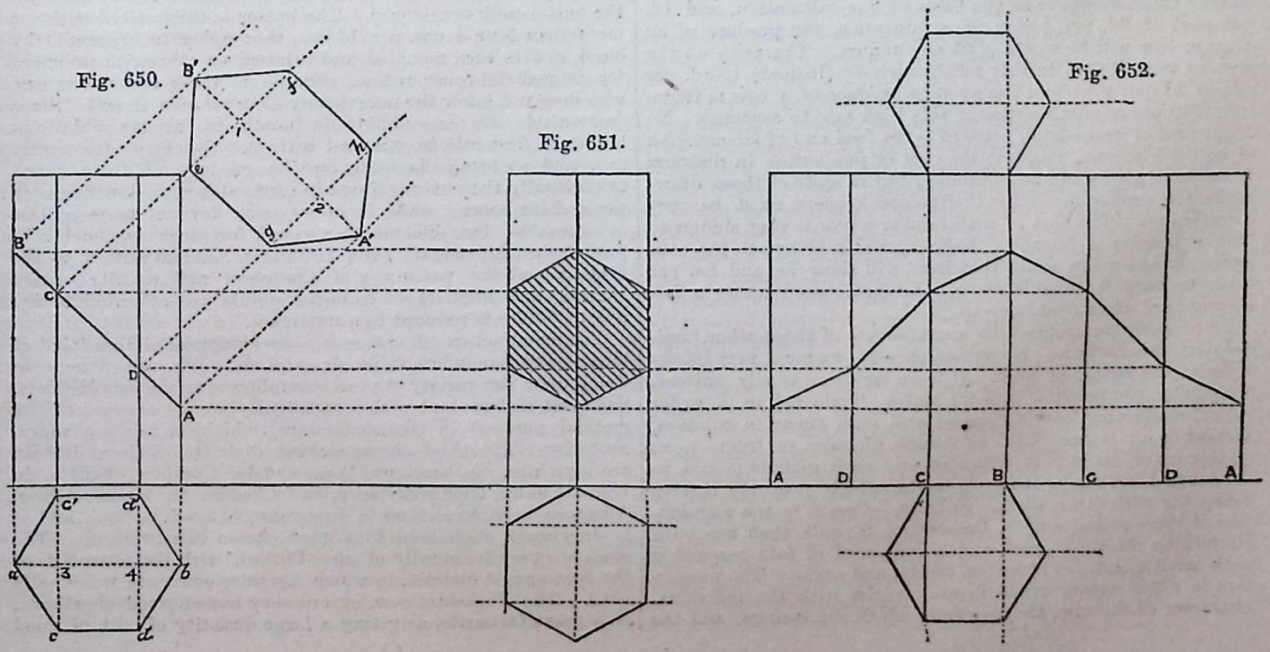
All sections of this pyramid, parallel to the base, are regular hexagons; therefore a perpendicular drawn from I to cut the plans of the edges E O and F O in *i'* and *i* will give *i i'*, the one side of the true section; and lines drawn from *i* and *i'* parallel to E D and F A will be two more, and thus the whole plan may be completed.

Similarly, Figs. 655 and 656 are the plan and elevation of the same pyramid when rotated on its axis so that two faces are parallel to the vertical plane.

Here the section line is seen cutting the elevation of the *edge* of the pyramid in A, and a perpendicular dropped to cut the plan of the edge in A' gives the radius of a circle which will contain the true section; from the centre, therefore, with radius O A', describe this circle, and this, cutting the other five radii of the hexagon, will give the hexagon which is the true section, as in the last figure.

We now proceed to draw the development of this pyramid, and here it will be evident that the exact size





could not be obtained from the elevation (Fig. 654), for the length of a o is not the true length, because it slants backwards; nor is the length f o the right length, because the base on which it stands, F O in the plan, is not parallel to the vertical plane, and thus f o is in a degree foreshortened.

In the elevation (Fig. 656), however, the line B O is the true length of the edges of the pyramid; therefore, from any point as O', with radius O' B, describe the arc (Fig. 657), and set off on it six distances equal to the side of the hexagon forming the plan. From each of the points draw a line to O', which will complete the development.

Now on each of these lines set off the length B A taken from Fig. 656. Join the points, and this will give the section line, thus completing the figure.

FARMING AND FARMING ECONOMY.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

XIX.—DAIRY HUSBANDRY.

DAIRY produce consists of milk, butter, and cheese, and the practice of those who are engaged in the management of cows depends in a great measure upon the fitness of their locality for the production and disposal of one or other of these commodities. New milk is always saleable in populous neighbourhoods, and railroads now bring it from even remote districts to the great centres of industry. The cattle plague during 1865-6 was an active cause in directing the attention of town dairymen to the plan now usually followed of drawing their chief supplies of milk from the country, and since that time of dreadful cattle mortality the character of the new milk business in London has become more that of importing than producing. This is in every way a change for the better, as there was but too much reason to believe that the highly artificial and forcing character of the feeding of town-kept cows, together with the inevitable confinement to which they were subjected, resulted in unwholesome and poor milk, as well as a high rate of mortality among the cows themselves. Some startling facts relating to the condition of the New York cow-stalls, which appeared in *Fraser's Magazine*, appealed both to the humanity and fears of the reader, and, no doubt, assisted the movement in favour of importation by rail rather than production in the town. The sale of new milk is manifestly the simplest method of disposing of the produce of cows, and where there is a demand no method will give so large a return. We have no wish to burden the reader with unnecessary statistics, but we may mention that a good cow may be expected to yield not far off 1,000 gallons of milk per annum, and that where large numbers of cows are kept, 600 gallons is looked upon as a very fair average. Taking this last figure as the basis of our calculation, and 1d. per pint or 8d. per gallon as a fair price, the produce of an average cow will be worth £20 per annum. The price at the present time (1872) in this neighbourhood (Redcar) is 1d. per gill or 2d. per pint, and the average produce of a cow is therefore £40 per annum, supposing this high rate to continue. No doubt rent of grass-land, price of extra food and of labour, risk of bad debts, etc., increase the cost of production in districts where such prices can be obtained; but in spite of these drawbacks the profits made by thrifty cow-keepers must be very considerable. The cost of maintaining a cow is very similar to that of keeping a fattening bullock, and a glance at the estimates already given under that head will show 7s. and 8s. per week to be a reasonable enough estimate, even where a fair allowance of extra food is given.

To properly understand the manufacture of those other familiar dairy productions—butter and cheese—we must very briefly consider the nature of milk. It is an emulsion of oily matters, principally composed of a solid and a liquid fat in a water (whey) containing casein (cheese) and milk sugar in solution. The fat or oil is suspended as minute globules of from $\frac{1}{2000}$ to $\frac{1}{5000}$th part of an inch in diameter, and each globule is said to be covered with a coating of casein, which prevents it from coalescing with other similar globules. Cream is the aggregation of these globules upon the surface of milk that has been allowed to remain at rest, and is composed of fats associated with small quantities of water, casein, and sugar. The proportion in which cream exists in milk varies with the individual character of the cow, the race from which she springs, and the food supplied to her. Mr. Morton quotes an authority from Gloucestershire who says: "20 quarts of milk in hot weather yield 1¾ quarts of cream, or about 9 per cent. in volume, and one-fourth more or 11 per cent. in colder weather." The average yield of Mr. T. Scott's English dairies, quoted before the Agricultural Society, was 1 quart of cream for every 12½ quarts of milk, or little more than 8½ per cent. His Irish dairies yielded 10 per cent. With regard to the amount of butter obtainable from cream, Mr. Horsfall informs us that when at grass his cows yielded cream which gave at the rate of 1 lb. of butter per quart of cream; but that when fed in winter upon rape-cake, bran, and other substances rich in oil, their cream has yielded 22 to 24 ozs. of butter per quart. When milk is churned an average yield of butter is 1 lb. per 20 pints of milk, and the amount varies from 1 lb. per 17 pints to 1 lb. per 25 or 26 pints. The average amount of butter made from one cow in the year has been found in the case of numerous dairies to vary from 218 to as high as 300 lbs.

The manufacture or making of butter is at once so simple, and yet so dependent upon practical experience rather than knowledge which can be communicated by the tongue or pen, that we propose to treat of it with the utmost brevity. Agitating the milk or cream in any sort of vessel causes the fatty globules above described to break and agglutinate together into a mass of butter. The process is conducted in a variety of ways, but the same principle of action prevails in all. The barrel slung upon a frame, and turned with two winch-handles, is one of the most familiar forms of churn. The interior of this simple apparatus is fitted with perforated shelves extending from the internal surface towards the centre, through which the cream passes as the barrel is turned. Plunge churns, in which a plunger or piston, also perforated so as to allow of its free passage up and down through the milk, are also in use, and where large quantities of milk are employed this is a good churn for working by steam-power. Milk or cream may be allowed to become sour before it is churned without injuring the quality of the butter, but it is not advisable to add any sweet milk in such case at churning time. Milk rendered sour during the act of churning yields butter-milk, which is liable to become rapidly rancid. Milk is churned at its natural temperature in summer, and is raised to 65° or 70° F. in winter by the addition of hot water. Cream is raised or lowered to 55° or 60° F. according to the weather. Churning proceeds with regular speed, turning the churn neither too fast nor too slow. When the butter falls from side to side in a compact lump the dairy-maid knows that her work approaches completion, and when she is satisfied that all the butter is gathered together the mass is taken from the churn and washed with cold spring water, or carefully kneaded in a shallow, empty wooden vessel until all the butter-milk is removed. The butter is then salted with not more than 3 or 4 ozs. per 14 lbs., thoroughly incorporated by hand, and is then moulded and printed, or otherwise prepared for immediate consumption. Simple as these operations are, who does not know the uncertainty that attends them? Some dairy-maids are exceedingly fortunate in always obtaining butter of first-rate flavour and texture. Others as frequently fail, and so bring disrepute on the produce of their dairy. Occasionally the butter refuses to form, although churning may proceed for hours; while in other cases flavours more or less disagreeable, but difficult to account for, lurk in the butter produced. Experience, care, cleanliness, and attention to the feeding and the pasturage of the cows will usually ensure success, and when these essential points are attended to the risk of failure is reduced to a minimum.

The manufacture of cheese is more complicated than that of butter, and demands a fuller description. We cannot hope to touch upon the variety of practices followed in various districts, but must rest content with a sufficiently minute account of the method pursued in Gloucestershire, which is fairly a representative. The chief cheese-making districts in Great Britain are Ayrshire, Cutherstone, Wensleydale, Cheshire, Stilton in Leicestershire, Gloucestershire, and Cheddar in Somersetshire. All these districts abound in first-rate old pasture-land, and it is only upon such land that good cheese can be made. The cows are very frequently of mixed breed, with the exception of the first-named district, in which Ayrshire cows are principally used. The Yorkshire cow, or ordinary unpedigreed shorthorn, is a great favourite, as giving a large quantity of milk of good

quality, and in a dairy of these cows an Alderney or two is often kept to add a greater richness to the general character of the milk. We shall consider cheese-making as at present carried out in the case of an ordinary Gloucestershire dairy, and afterwards turn our attention to another point of interest in the manufacture of cheese—namely, the introduction of the factory system from America.

Bearing in mind the composition of milk, it will be seen that butter and cheese are composed of the same constituents mingled together in very different proportions. Butter is the collected fats of milk associated with small quantities of casein, water, and sugar. Cheese is the casein of milk associated with butter, water, sugar, and ashy materials. The following analysis of various kinds of cheese taken from Mr. Morton's "Hand-Book of Dairies" will show at once their composition and the proportion which the ingredients bear to each other in every 100 parts :—

Ingredients per Cent.	Skim Milk Cheese.	Double Glo'ster.	Cheddar.	North Wilts.	N. Wilts. 2nd specimen	Dunlop.
Water. .	43·82	35·81	36·04	35·58	44·80	38·46
Casein. .	45·04	37·96	28·98	25·00	28·16	25·87
Butter .	5·98	21·97	30·40	30·11	23·04	31·86
Saline matter . .	5·18	4·25	4·58	6·29	3·99	8·81

Cheese-making consists in causing the separation of the casein from the slightly alkaline watery fluid in which it has been previously dissolved, and in doing so the more butter is precipitated with the curd the richer will the cheese be. This separation may be effected by natural means by allowing the milk to become sour, or by the introduction of an artificial ferment. This latter plan is followed, and the substance used is termed *rennet*. "It is essentially a decoction of animal membrane, or other animal substance in which a certain degree of chemical change has been permitted, and is, indeed, in progress." Calves' stomachs, either with or without their contents of curdled milk, are salted and packed away under the name of "vells." These vells are purchased in the winter at the rate of two to each cow, and six of them are placed in every two gallons of a saturated brine. A thirty or forty gallon cask may be prepared at once, and a constant supply of rennet be thus ensured.

Cheese-making may commence as early as the latter part of March, but more usually in April, and it is continued as late as October. Milk in early spring is used for feeding or fattening calves, or for butter-making, and is not considered very suitable for cheese. The cows are newly calved, and their milk is not suitable for the manufacture of cheese; the supply is also scarcely yet constant in quantity, and all these reasons cause cheese-making to be put off for awhile. We shall suppose then that April is well advanced, and that the work of cheese-making has become a regular daily employment. The utensils required in the cheese dairy are a cheese-tub large enough to hold all the milk of the cows; a "ladder" to lie over the tub; a straining sieve; skimming-dish; cheese vats or moulds turned out of solid elm wood; "suity boards," or round discs of elm made to fit the vats when there is not sufficient curd to completely fill them; a stone or iron cheese-press; shallow lead vessels for receiving the whey; pipes to drain off the whey to a cistern from which it is pumped into the pigs' troughs; usual vessels for milk and cream, and for butter-making.

The cheese-tub occupies the middle of the floor, and the morning and evening's milk is poured into it through a hair-cloth sieve. The following are the progressive steps in the operation :—

1. The milk must be brought up to the temperature of 80° F. by heating a portion, if necessary, in a vessel placed in boiling water. This is important, as, if the milk is too cold, the curd will be tender, and if too hot it will "heave."

2. The colouring matter or annatto is added, although this is less commonly done now than formerly.

3. The "rennet" is added in the proportion of half a pint to 50 gallons of new milk, or 75 gallons of skim milk.

4. A short time is allowed to elapse, and the curd which has now formed is cut in two directions at right angles to each other and around the edges with a long thin-bladed knife that reaches down to the bottom of the tub.

5. The curd is allowed to sink for a quarter of an hour, and some of the whey is dipped out, after which it is again slowly cut into very small pieces.

6. The curd now settles into a compact mass, and more whey may be removed.

7. Heap the curd into the middle of the tub bottom, which is convex.

8. The mass is cut through in several places to favour the escape of the whey.

9. Place the curd in vats, and subject it to pressure for about half an hour.

10. Break the curd into pieces about the size of vetches either by hand, or, better still, by means of a curd-mill.

11. The curd is once more placed in the vats, and a little scalding water thrown over it when the vat is full.

12. The "cheese" is now turned out of the vat or mould into a thick canvas cheese-cloth, and again placed in the vat completely enveloped in the cloth.

13. When the cheese has been two hours in the press it should be removed, and the wet cloth exchanged for a dry one.

14. The cheeses made in the morning are salted at night for the first time, and this is done three to four times by rubbing in the salt according to the thickness of the cheeses. Twelve hours should elapse between each salting.

15. The cheeses are turned in the vats every day, and remain in the press four days or longer. They are then taken out and placed upon the shelves, where they are also regularly turned and kept from draughts.

The various kinds of cheeses which divide the public favour owe their character to differences in the manipulation of the curd, the character of the pasture, and other less evident peculiarities in their manufacture. In Ayrshire the milk is heated to 85° or 90° F., when the rennet is added, and the consequence is a very rapid setting of the curd. Cheddar cheese is made by first adding rennet, as already described in Gloucestershire practice. The curd is afterwards finely broken and actively stirred in the whey, which is heated by drawing off a portion, placing it in a vessel in boiling water, and returning it to the remainder. This is done twice: the first time heating the whole mass up to 80° F., and the second time to 100° F. Half a pound per cent. of salt is added to the crumbled curd. A Stilton cheese is made from 9 gallons of new milk, and the cream of 2 to 3 gallons of milk. Lambs' stomach is used as the basis of the rennet, and when the curd is set it is not broken as in Gloucestershire, but it is laid upon a canvas strainer in a cheese-basket. After a few hours, when sufficiently firm, it is laid in the vat in slices, and salt is sprinkled between each layer. Its own weight is sufficient pressure, and it is turned every two or three hours for the first day, and two or three times the next day. The cheese must remain in the vat three or four days.

Cheese-making is done once or twice a day, and entails an immense amount of labour upon the farmer's wife and daughters, as the burden of the operation falls principally upon them. It is this severe tax upon the household which has caused the recent movement in favour of cheese factories after the American models. In these factories the best methods can be adopted and carried out with an accuracy which can scarcely be looked for in a farm-house. Division of labour and constant practice will also greatly improve the skill of the manufacturers; strict economy in labour and material will be possible; while at the same time the farmer's family will be relieved of a severe and irksome responsibility. A most interesting report upon the Derbyshire Cheese Factory Association was contributed by Mr. Gilbert Murray to a recent volume of the "Royal Agricultural Society's Journal." The first cheese was made on the 8th of April, 1870, and the factory was in full operation upon and after August 28th. From this time to September 30th from 4,000 to nearly 5,000 lbs. of milk were daily received, and the amount of cheese made varied from 400 to nearly 500 lbs. per day, thus proving what has often been stated, that 1 gallon (10 lbs.) of milk makes 1 lb. of cheese. A cow in a well-managed dairy will yield from 4 to 5 cwts. of cheese in the summer, and about 10 lbs. of whey butter. The whey from a cow is sufficient to maintain one hog, and its value is estimated at £1.

GUTTA-PERCHA.—I.

BY GEORGE GLADSTONE, F.C.S.

DISCOVERY—ISONANDRA GUTTA—MODE OF COLLECTION—DESTRUCTION OF TREES—COMPOSITION—CHEMICAL PROPERTIES—PHYSICAL PROPERTIES.

THIS most useful substance was unknown in Europe until the year 1843, when it was almost simultaneously introduced to the public notice by Dr. Montgomery and Messrs. D'Almeida and Sons, of Singapore. Its resemblance to Indian rubber in many of its properties ensured for it a ready reception; and the enterprising manufacturers who had already applied caoutchouc to such a great variety of uses, took up the new article, and adapted it to various purposes, either in substitution for, or in combination with the former.

Gutta-percha is the inspissated juice of the *Isonandra Gutta*, a tree growing commonly in the island of Singapore, and on the Malay Peninsula, and in many of the principal islands of the Eastern Archipelago. It belongs to the genus *Sapotaceæ*, several of which yield a useful product, though none of the others will vie with the *Gutta*. The *Isonandra* frequently grows to the height of about seventy feet; and the trunk, which is always very thick in proportion to the height of the tree, sometimes attains a diameter of six feet; but trees of such dimensions are probably of great age, as it appears to be of very slow growth. The character of the foliage will be best understood by a reference to the drawing, which represents a portion of a branch with the leaves, flowers, and fruit. The wood is soft and spongy, and of a light colour, but traversed longitudinally by black lines which indicate the course of the channels that contain the juice; these lie immediately under the bark.

The plan of collecting the gutta-percha which was adopted at first by the natives was a very uneconomical one; but this was partly occasioned by the greatness of the demand which suddenly sprung up on the opening of the English market. This, and the very high price which it consequently fetched, incited the Malays to produce the greatest possible quantity at the time, regardless altogether of the future. They accordingly cut the trees down immediately above the root, and then cut rings through the bark of the prostrate trunk, about twelve to eighteen inches apart, from each of which the milky sap exuded. Cocoa-nut shells, or any other convenient vessels for collecting it, were placed under each incision; and as soon as the juice began to coagulate, which would happen after a few minutes' exposure, it was taken out and kneaded by hand into balls or lumps. Each tree would yield on an average about 15 pounds of gutta-percha.

So great was the destruction of trees in this way, the shipments from Singapore during the year 1848 being equivalent to the loss of 100,000 trees, that great fears existed at one time, lest the supply should be utterly cut off; and considerable exertions were made to establish the system of periodical tapping. The island of Singapore itself, which yielded the earliest supplies, was, as may be expected, very speedily denuded of all the gutta trees of any considerable growth; but explorations were made of all the most likely regions in the neighbourhood, and these showed that the trees occupy a very wide district, extending from Penang in one direction, to the south side of Borneo in the other, and that they often constitute a leading feature of the vegetation in the warm and moist alluvial lands lying between the hills and the sea-coasts. With a judicious mode of collection no fears need therefore exist on this score, though the price of the raw article may be such as to limit its application to those purposes for which it is specially valuable.

The milk is now very generally collected from incisions in the living trees, and worked up into blocks by the hand as already described. In some places where the juice is collected in large quantities, it is conveyed in bamboos to the boiling-house, and the watery portion driven off by the aid of artificial heat. The gutta is imported in cakes or lumps of very irregular size, just as they are made. These are of a variegated dirty brown colour, containing a good deal of dirt, chips of wood, and other impurities; even when not fraudulently adulterated by the natives for the sake of increasing the weight.

In composition it appears to be almost exactly the same as caoutchouc—a hydrocarbon consisting of about 89 per cent. of carbon, and 11 per cent. of hydrogen; and in many of its properties it also bears a strong resemblance, though greatly differing in others. Probably, in consequence of the rude way in which it is prepared, the gutta of commerce always contains more or less resinous compound, caused by the partial oxidation of the pure substance. A good sample of the ordinary article has been found to consist of the following:—

Pure gutta	79·70
Soft resin	15·10
Vegetable fibre	2·18
Moisture	2·50
Ash	0·52
	100·00

The analysis, deducting moisture and ash, giving—

Carbon	84·66
Hydrogen	11·15
Oxygen	4·19
	100·00

The pure gutta is easily separated from the rest by dissolving up the commercial article in any solvent, and then precipitating the gutta by adding alcohol, which will form a milk-white coagulum, consisting of the pure hydrocarbon. When thoroughly dissolved in such articles as bisulphide of carbon or chloroform it can be easily filtered; but this operation must be conducted under a bell jar, to prevent the evaporation of the solvent during the process. The filtrate will be quite clear and almost colourless, and when the solvent is allowed to escape, pure gutta will be left behind.

In chemical properties the two substances, caoutchouc and gutta-percha, bear a strong resemblance. The reader is here asked to compare the following points with those given respecting Indian rubber in Articles I. and II. under that heading (see pages 104 and 156), so as to save unnecessary repetition; and for convenience of reference they will be given as nearly as possible in the same form.

Insolubility in Water.—It is perfectly so in water at any temperature, a circumstance which will be seen to be of especial importance when we come to consider its application to oceanic telegraphy. Thus Professor Miller, in his report presented to the Committee of Privy Council for Trade on the decay of gutta-percha and caoutchouc, says—"As the general result of these inquiries, I find that whenever the gutta-percha has been completely submerged in water no injurious change has occurred, sea-water appearing to be eminently adapted to the preservation of the gutta-percha." The experiments from which this conclusion was derived were similar to those to which the caoutchouc was submitted, described in Article IV. All the samples protected by either sea or fresh water, and whether exposed or not to the action of air and light, were wholly unaltered after a lapse of nine months, "with the exception of a slight increase in weight, due to the absorption of water, which they lost again after the exposure to the air for an hour or two. The tenacity and structure of the material did not appear to have undergone the slightest change." Its impermeability to water at once suggests its possible value as a waterproofing material, its advantage over leather in the soleing of shoes, and its application to all those purposes for which Indian rubber had previously been used, and which depended upon this property.

Resistance to the action of Alkalis.—None of these, even when caustic, exercise any influence whatever; nor do any saline solutions.

Effect of Acids.—Like Indian rubber, it is rapidly decomposed by strong nitric acid, and slowly by concentrated sulphuric acid, but the other acids have no effect upon it. Even hydrofluoric acid will not touch it, so that gutta-percha bottles are ordinarily used to hold it, though it appears that the fluorine will notwithstanding find its way through the substance of the bottle in sufficient quantity to corrode the surface of any glass which may stand for any length of time in immediate proximity to it.

Sulphur produces upon gutta-percha an action analogous to the vulcanisation of caoutchouc; and as a manufacturing process of considerable importance, it will have to be spoken of in greater detail presently.

Insolubility in Alcohols and Fermented Liquors.—The similarity between the two substances holds good here also. The

former will scarcely dissolve pure gutta-percha, if at all; the commercial article will always be somewhat affected by it, because it is never free from admixture with a resinous product due to a slight oxidation of the gutta. No fermented liquors will attack it at all, and it will withstand the action of anything which tends to excite fermentation in other articles. Ether which is absolutely free from alcohol will dissolve it, but the effect of the least trace of the latter is as complete in this case as in that of Indian rubber.

Solvents.—Bisulphide of carbon and chloroform are the best, as they will act upon it in the cold. Benzole and oil of turpentine will do so to some extent at any time, but require the aid of heat to dissolve it completely. Linseed oil, whether boiled or not, Stockholm and coal tar, have no effect, but such as is of a preservative nature.

Oxidation.—We have in gutta-percha a strictly analogous instance of the effect of the direct action of the solar rays in promoting the absorption of oxygen from the atmosphere. Professor Miller found that "alternate exposure to moisture and dryness, particularly if at the same time the sun's light has access, is rapidly destructive of the gutta-percha, rendering it brittle, friable, and resinous in aspect, and in chemical properties. A gradual absorption of oxygen takes place, and the gutta-percha slowly increases in weight, becoming at the same time proportionately soluble in alcohol, and in dilute solutions of the alkalis." 500 grains of thin sheet gutta placed in an open bottle, but inverted, so as to be open to the air and light, but excluded from rain, gained in weight 24·5 grains in nine months, by the absorption of oxygen. "The outer layers of the sheet, where exposed to light, were brittle and resinous in appearance, but the inner portion, which had been screened from light by the outer folds, was but little altered in texture or appearance." 55 per cent. of the mass had been transformed into resin, while a similar sample in an open bottle, but kept in the dark, had only increased 2·5 grains in weight, and when treated with alcohol only gave up 7·4 per cent. of resinous matter.

BLOSSOM AND FOLIAGE OF THE GUTTA-PERCHA TREE.

In all these particulars gutta-percha will be seen to bear a very general resemblance to caoutchouc, but many of the physical properties will be found to be widely different.

Structure.—Instead of being gelatinous in character, and without any perceptible structure, gutta-percha appears under the microscope to be as full of holes as a sieve. This is easily shown by taking a drop of solution, putting it upon a glass, and then evaporating out the solvent; a thin transparent film will thus be obtained, in which the pores will be readily detected. If a drop of water is then added, it will be seen to find its way gradually into the cavities, which will become distended by the liquid.

Specific Gravity.—In consequence of its porosity, this is ascertained with difficulty. The commercial article is usually about 0·97, or a trifle lighter than water; but by manipulating it under water, so as to discharge the air from the pores, it will gradually become heavier, and ultimately cease to float.

Extensibility.—Though at first gutta-percha appears to be devoid of any fibrous structure, and is indeed but a coagulated sap, and therefore without any organic tissue, a fibrous character can be imparted to it, and it is then capable of extension in one direction to about double its original length, while if the tensile force is applied to what may be termed the crossway, it will break instead of yielding to the strain. In this respect, therefore, it bears no resemblance whatever to Indian rubber; and it is moreover practically devoid of elasticity.

Pliancy.—Herein lies one of its chief excellences, which renders its manipulation so exceedingly simple, and causes it to be applicable to such a variety of purposes. At the ordinary temperature of this climate, it has about the same tenacity and flexibility as leather of equal thickness; but as the temperature is raised it becomes softer, though still tough up to about 120° Fahrenheit; and when the heat is carried above 150° it becomes so soft and plastic that it can be easily moulded in any form, which it will strictly retain on cooling. Between that temperature and 240° it can be rolled out into thin sheets, or drawn out into threads, and will always return to its original firmness and tenacity on being cooled again. The greatest degree of cold ordinarily experienced in this country only slightly diminishes its flexibility.

Decomposition by Heat.—It burns readily with a bright flame. At 248° it melts; and on boiling it gives off abundant vapours, which condense into a colourless oil.

Non-conduction of Electricity.—In this respect it resembles Indian rubber, and is indeed equal to shellac as an insulator, while it has the advantage over the latter in not being brittle. It supersedes the former article in submarine telegraphy, as it possesses generally at least equal advantages, and can be manipulated with greater ease and less risk of loss of electric power from defective workmanship. So efficient is it as an insulator that it will retain its character under atmospheric conditions which would make the surface of glass a good conductor of electricity. When subjected to friction it becomes negatively electric. It is likewise a bad conductor of heat.

Its acoustic properties also stand very high, and on this account it is eminently fitted for the manufacture of speaking-tubes from one room or floor to another, which are now commonly used in manufactories and all large commercial establishments; while they are to be found occasionally in private dwellings.

It will be seen from the foregoing summary of the chemical and physical characteristics of gutta-percha, that while it has much in common with caoutchouc, it has at the same time sufficient specialities to render it a valuable help-meet to its elder brother; and in the sequel it will be found that while many of the manufacturing processes are almost identical, the fact of its readily yielding to a moderately warm temperature renders many of the operations much more simple and easy in their application than those which have to be adopted in the case of Indian rubber.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXV.—WILLIAM HARVEY: CIRCULATION OF THE BLOOD.

It has been remarked that contemporaries are seldom grateful to discoverers; and it is a striking corroboration of the truth of the remark, that only at the moment we write has it been decided to raise one of England's greatest scientific celebrities from the ungrateful forgetfulness to which he has been hitherto consigned. Such has been the world's treatment of the illustrious William Harvey, whose discovery of the fact of the circulation of the blood has given an imperishable glory to the name of Harvey, and placed him in the foremost rank of natural philosophers; but he who raised physiology from mere guesswork is at length to be honoured by the erection of a national memorial. A committee is in process of formation in London, to assist a committee at Folkestone, the birthplace of Harvey; and public scientific bodies and individuals are being asked for aid and co-operation. We gather from the report of a public meeting held at Folkestone, that Mr. Simon, the Medical Officer of the Privy Council, has warmly advocated the movement, and in the course of an eloquent speech made the following observations:—"Harvey, in teaching the fact of the circulation of the blood, in teaching what duty is done by each beat of the heart, in relation, on the one hand, to the function of respiration, and on the other hand, to the nourishment of all textures of the body, gave us our first groundwork of animal physiology. It is no exaggeration to say that in giving to the world that first precise knowledge of the circulation of the blood, he laid the indispensable foundations for all physiology that has followed or can follow; and surely this achievement by our countryman is something for us all to honour and be proud of." To this we may add that the Rev. Matthew Woodward, Vicar of Folkestone, and the churchwardens, are soliciting small contributions towards this national object. They propose "to fill the large west window of Folkestone Church with eight subjects chosen from our Lord's miracles of healing, and record, on a brass underneath, Harvey's great discovery, for which the whole human race has to be profoundly thankful."

William Harvey was born at Folkestone, in Kent, on the 1st of April, 1578, in a house of fair stone, which Harvey left by will, together with some land adjoining, to Caius College, Cambridge. At ten years of age he was sent to the grammar school in Canterbury; and having there laid a proper foundation of classical learning, was removed to Gonville and Caius College, Cambridge, and admitted as a pensioner in May, 1593. After spending five years at the university, to acquire medical knowledge, he travelled through France and Germany, and fixed himself, in his twenty-third year, at Padua University, where he diligently attended the lectures of Fabricius ab Aquapendente on anatomy, of Minadous on pharmacy, and of Casserius on surgery. He taught the existence of valves in all the veins of the body; and from that moment Harvey endeavoured to discover the use of these valves, his success in which inquiry was the foundation of his after fame. He took his doctor's degree at Padua in 1602, and returned home at the age of twenty-four; in the same year he again graduated at Cambridge, and settled in the practice of his profession in London. In 1604 he was admitted to the College of Physicians; and in 1615, when thirty-seven years old, he was appointed reader of the anatomical and surgical lectures at the College. He was next appointed physician to St. Bartholomew's Hospital [1619–1645], and the rules which he laid down for the duties of the medical officers of the hospital were adhered to for nearly a century after his retirement. ("Journals of the Hospital: Records of Harvey.") Writing of him, Aubrey says:—"His brother Eliab bought, about 1654, Cockaine House, now [1680] the Excise Office, where the doctor was wont to contemplate on the leads of the house, and had his several stations in regard of the sun or wind. He [Harvey] was much and often troubled with the gout, and his way of cure was thus: he would then sitt with his legges bare, if it were frost, on the leads of Cockaine House, putt them into a payle of water, till he was almost dead with cold, and betake himself to his stove, and 'twas gone." Harvey now seriously prosecuted his researches on the circulation of the blood, in the course of which he first publicly announced these doctrines; he read his lectures at the College of Physicians, in Amen Corner; and in the present College in Pall Mall East are seven preparations by him. Many years of experimental verification elapsed before he published these doctrines in 1628.

The importance of this remarkable discovery was great. Boyle, in his "Treatise on Final Causes," states that in the only conversation he ever had with Harvey, he was told by him that the idea of the circulation was suggested to him by the consideration of the obvious use of the valves of the veins, which are so constructed as to impede the course of the blood from the heart through these vessels, while they permit it to pass through them to the heart. Before the time of Harvey, the opinions on the circulation were numerous and inconsistent. The blood was supposed to be distributed to the various parts of the body by means of the veins, and that intended for the nutrition of the lungs by the action of the right side of the heart. According to the same doctrines, the arteries were destined for the conveyance of the vital spirits, which were formed on the left side of the heart from the air and blood derived from the lungs. Opinions did not agree as to the mode in which the blood found its way to the left side of the heart, some supposing it to be conveyed with the air from the lungs, others maintaining it to be transmitted by certain imaginary pores in the septum between the ventricles. These opinions, it is evident, rested more upon the imagination than any careful observations upon the facts. Those of Harvey, on the contrary, were drawn from the most accurate dissections of dead and living animals, and supported by arguments depending entirely upon the anatomical structure and obvious uses of the parts. Now there is historical evidence to prove that, although Harvey discovered the *fact* of the circulation of the blood, he did not discover the *course*, nor the *causes* of the circulation. He knew that the blood was carried from the heart, through the arteries, to the tissues, and from the tissues, through the veins and lungs, back again to the place whence it started. But he knew not *how* the blood passed from arteries to veins; he knew not *why* the blood thus moved. In our day, the exact course is known, but the exact *causes* are still under question. We know that the circulating system consists of heart, arteries, capillaries, veins, and lymphatics. Harvey knew not the capillaries and lymphatics. To estimate what he actually discovered, we will take a rapid view of the circulation.

The heart, as the great centre, shall be our point of departure. It is composed of four cavities, or *ventricles*. Into the right auricle the blood is poured by the veins; it passes thence into the right ventricle, and is driven therefrom, by a strong contraction called the *pulmonary artery*, into the lungs. Here it comes in contact with the oxygen of the atmosphere, and changes from venous into arterial blood. It now passes along the *pulmonary veins* into the left auricle of the heart, thence into the left ventricle, from which it is driven by a powerful contraction into the arteries. The pulsing torrent rushes through the arteries into the various tissues, where it passes into the network of capillary vessels. Having served the purpose of nutrition, the blood continues its course along these capillaries into the veins. Hence the stream is joined by that of the lymphatics, which, like the roots of a plant in the earth, absorb lymph from the organs in which they arise. This confluence of streams hurries on till the blood is emptied into the right auricle, from which it originally started; and thus is the circuit completed.

Still, the two centuries which have elapsed since Harvey's discovery have not sufficed entirely to complete it. Three capital errors, for sixteen centuries, marked the fact of circulation. First, that the arteries did not contain blood. Secondly, that the two chambers of the heart communicated with each other by means of holes in the septum dividing them. The third error was that the veins carried the blood to the various parts of the body. The first of these errors was, in part, set aside by Galen's proving that the arteries did carry blood; but the composition of the atmosphere being unknown in his days, it remained for modern science to prove that atmospheric air is not contained in the arteries, but only the oxygen thereof, with a slight amount of nitrogen, and a certain amount of carbonic acid gas. The second assertion, of the holes in the septum, was disproved in 1543, by Vesalius, the father of modern anatomy. The third error, that of the veins carrying the blood to the tissues, was disproved by Michael Servetus, showing that the two bloods, venous and arterial, pass one into the other in

the lungs, or by the pulmonary circulation. This he showed in a work which was burned by the theologians; and Servetus himself was subsequently burned for speculations of another kind. Servetus has plainly described the passage of the blood from the heart to the lungs, where it is agitated, prepared, and changes colour, and is poured from the pulmonary artery into the pulmonary vein. This, however, was but a guess, and was soon forgotten. Six years later, Colombo re-discovered the pulmonary circulation, and then Cæsalpinus, the famous botanist, unaware of what Colombo had written, announced the same discovery as his own, and was the first to pronounce the phrase "circulation of the blood." However, the true theory of *pulmonary* circulation remained for Harvey to discover. Servetus, Colombo, and Cæsalpinus, we have seen, knew that the blood passed through the lungs, but they conjectured that only so much passed as was requisite for the reception of the *vital spirits*, which, their predecessors fancied, passed through the perforated septum of the heart. They, however, had no conception of the entire mass of blood traversing the lungs. The discovery by Fabricius, in 1574, that the veins had valves, which opened and closed like doors, brought the discovery of the circulation within compass. These valves did not prevent any flow from the heart, but admitted it, which, it has been observed, ought to have suggested to the discoverer their use; but nearly half a century elapsed before the real object and purpose of this anatomical structure in respect to the blood-current was perceived. In the interim every anatomist of the great Paduan school in which Harvey studied was familiar with the circulation. Yet, when he promulgated its theory, it was ill received, most persons opposed it, others said it was old, and very few agreed with him.

No one, except Harvey, had for nearly half a century seen the significance of the fact; and he not only conceived a clear idea of the process, but described it minutely and accurately. Having, about the year 1620, succeeded in completely tracing the circle in which the blood moves, and having at that time collected all the evidence of the fact, with a rare degree of philosophical forbearance, Harvey still spent no less than eight years in re-examining the subject, and in maturing the proof of every point, before he ventured to speak of it in public. The brief tract, which at length he published, was written with extreme simplicity, clearness, and perspicuity, and has been justly characterised as one of the most admirable examples of a series of arguments deduced from observation and experiment that ever appeared on any subject.

Perhaps, during these eight years of re-examination, the discoverer of the circulation sometimes endeavoured in imagination to trace the effect which the stupendous fact, at the knowledge of which he had arrived, would have on the progress of his favourite science; and it may be, the hope and expectation occasionally arose, that the inestimable benefit he was about to confer on his fellow-men would secure to him some portion of their esteem and confidence. What must have been his disappointment when he found, after the publication of his tract, that the little practice he had had as a physician by degrees fell off. He was too speculative, too theoretical, not practical. Such was the view taken by his friends. His enemies saw in his tract nothing but indications of a presumptuous mind, that dared to call in question the revered authority of the ancients; and some of them saw, moreover, indications of a malignant mind, that conceived and defended doctrines which, if not checked, would undermine the very foundations of morality and religion. When the evidence of the truth became irresistible, then those persons suddenly turned round, and said that it was all known before, and that the whole merit of the vaunted discoverer consisted in having *circulated the circulation*.

But the epithet *circulator*, in its Latin invidious signification (quack), was applied to Harvey by many in derision, and it was believed by the vulgar that he was crack-brained. Nevertheless, about twenty-five years after the publication of his system, it was received in all the universities of the world; and Hobbes has observed that Harvey was the only man, perhaps, who ever saw his own doctrines established in his lifetime.

The opposition to the new system has, however, been greatly exaggerated by historians. It is true that the faculty rejected it, but eminent men adopted it. Guy Patin did not spare his opposition, which, however, Molière laughed at; and Boileau ridiculed the faculty. The great Descartes warmly espoused the doctrine. Swammerdam and Malpighi, two of the greatest names of the century, speak of Harvey with reverence, and soon no one spoke of him in any other tone.

The course of the circulation was not, however, known to Harvey; nor could he have traced it with the means at his disposal. But four years after Harvey's death, in 1661, Malpighi, by aid of the microscope, detected those capillaries which form the channel of communication between the arteries and the veins. Nevertheless, Leuwenhoeck, in 1668, discovered more than fifty circulations of the blood in different places in the tail of a tadpole. Leuwenhoeck saw that not only the blood in many places was conveyed, through exceedingly minute vessels, from the middle of the tail towards the edges, but that each of these vessels had a curve or turning, and carried the blood back towards the middle of the tail, in order to be conveyed to the heart. "Hereby," says Leuwenhoeck, "it appeared to me that the blood-vessels I now saw in this animal, and which bear the names of arteries and veins, *are, in fact, one and the same*, that is to say, that they are properly termed arteries, so long as they convey the blood to the farthest extremities of its vessels, and veins when they bring it back towards the heart." Thus, then, was the demonstration of the course of the blood completed.

In the whole of the circulation controversy, the discretion and rare modesty exhibited by Harvey afford the best model for naturalists and scientific writers. He had been so much disgusted by the disputes in which he was involved on the publication of his views on the circulation of the blood, that he had determined to publish nothing more, and it was only at the earnest request of his friend, Dr. Ent, that he was induced to allow his "Exercitationes de Generatione" to be printed. This work consists partly of a commentary upon the writings of Aristotle and Fabricius on the same subject, and partly of details of his own observations and experiments. We have not space for an abstract of these papers; but we may remark that Harvey was aware that the vitellus is drawn into the intestine of the chick shortly before hatching, and serves for its early nutriment; and in this relation he well compared it to the milk. This fact was known to Aristotle. He corrected the error of Fabricius, who supposed that the egg is chipped by the hen, and showed, on the contrary, that this process is performed by the chick itself. He also noticed the late union of the upper parts of the upper lip, and assigned it as a cause of the frequency of hare-lip.

In 1623 Harvey was appointed physician extraordinary to James I., with a promise of succeeding on the first vacancy to the physicianship in ordinary, the duties of which he actually performed. He was afterwards physician to Charles I., and was in the habit of exhibiting to him and the most enlightened persons of his court, the motion of the heart, and the other phenomena upon which his doctrines were founded. There is an anecdote current of Dr. Harvey attending a young nobleman, who, owing to a natural defect, had an open fissure in his side, through which the action of the heart might be watched, and the mode of the circulation demonstrated. The physician procured an interview with Charles, and explained the strange *lusus naturæ* infinitely to his satisfaction. His observations on the process of generation in mammalia were confined chiefly to the deer species, of which he was enabled to obtain numerous specimens by the liberality of Charles I., who allowed him to take them from the royal parks. Among Harvey's dissections was that of "Old Parr," who died at the age of 152 years and nine months; his body, by the King's command, was dissected by Harvey, who attributed Parr's death to peripneumony, brought on by the impurity of the London atmosphere and sudden change of diet. During the Civil War, Harvey travelled with the King, and at Oxford was made by him Master of Merton College, and received the degree of Doctor of Medicine. He held the Mastership for only a few months, when Brent, who had been expelled by the King for favouring the Parliamentary cause, was replaced by that party, which had now gained the ascendancy. Soon after, his house was plundered and burnt by the same party, and, unfortunately, several unpublished works —of which we have only notices in his other writings—were destroyed.

The latter portion of Harvey's life was chiefly spent at his country house at Lambeth, or at his brother's near Richmond.

The Doctor's visits to his patients were made on horseback, with a footcloth, his man following on foot, in the same way in which the judges were then accustomed to ride to Westminster. In 1654 he was elected President of the College of Physicians, but in consequence of his age and infirmities he was induced to decline that honourable office; but he testified his regard for the Society by presenting them with his library, and conveying over to them, during his lifetime, a farm which had been left him by his father.

He died June 3rd, 1657, in the eightieth year of his age, and was buried in a vault belonging to his family, built by his brother Eliab at Hempstead, in Essex, where a handsome monument was erected to his memory. Aubrey attended his funeral, and says:—"Hee helpt to carry him into the vault; that he is *lapt in lead*, and on his breast in great letters, Dr. William Harvey." This statement is perfectly correct, and Harvey's coffin is to be seen in the vault along with those of other members of his family. The shape of Harvey's coffin is curious: it resembles that of an Egyptian mummy-case, being of the human form without the appearance of the arms. It is entirely of lead; there is no wooden cover, and literally on the heart is the name of the deceased, as described by Aubrey. A few years ago, the tomb had fallen into decay, when various plans of restoration were proposed, but nothing done. There is a fine portrait of Harvey in the Library of the College of Physicians. He built also a museum in the garden, upon the site of the present Stationers' Hall; the original college buildings were destroyed in the Great Fire; and the college in Warwick Lane was taken down a few years since. The Harveian Oration (in Latin) is delivered annually by a Fellow, usually on June 25th.

Mr. Wharton Jones read to the British Association, in 1852, a paper "On the Forces by which the Circulation of the Blood is carried on," containing a physiological discovery of very great importance. In the wing of the bat the main impulse to the circulating fluid is, as in other animals, given by the heart; but, in addition, Mr. Jones has discovered that while the walls of the veins in this animal contract rhythmically, like those of the heart, and any regurgitation being prevented by numerous and appropriately-placed valves, they thus very materially assist in forcing the blood onwards.

TRADE-MARKS.—I.

By A Barrister.

WHAT THEY ARE: RIGHTS OF PROPERTY.

The subject of patents which we recently discussed has suggested the treatment of the analogous subject of trade-marks in a similar form. It is hardly necessary to explain to our readers what a trade-mark is, as a matter of fact. Every commodity capable of bearing a trade-mark, from bricks to bottled beer, bears a trade-mark if it be desirable to distinguish it from other commodities of a similar nature. The Legislature has defined what a trade-mark is to include, namely (25 and 26 Vict., cap. 88), "any and every such name, signature, word, letter, device, emblem, figure, sign, seal, stamp, diagram, label, ticket, or other mark as aforesaid lawfully used by any person to denote any chattel, or (in Scotland) any article of trade, manufacture, or merchandise, to be an article or thing of the manufacture, workmanship, production, or merchandise, of such person, or to be an article or thing of any peculiar or particular description made or sold by such person," and also "any name, signature, word, letter, number, figure, mark, or sign, which in pursuance of any statute or statutes for the time being in force relating to registered designs, is to be put or placed upon or attached to any chattel or article during the existence or continuance of any copyright or other sole right acquired under the provisions of such statutes or any of them." That is a sufficiently elaborate definition, but notwithstanding the many forms which a trade-mark may assume, the classes into which trade-marks may be divided are two only. The present Master of the Rolls, in a case of Hall *v.* Barrows, took considerable pains to go into the history of the subject, and he said, "Trade-marks are commonly either of one or the other of two descriptions—either they denote the spot where certain articles are manufactured, or they denote the persons by whom they are manufactured." Then it is to be observed that a mark or symbol alone is of no use; property cannot be acquired in it unless it is attached to a vendible commodity. This was fully discussed in the famous Anatolia liquorice case, before Lord Westbury, it being contended that there could be no property in the word Anatolia, as it was the geographical designation of a whole country. Lord Westbury dealt with the argument in this way:—"Property in a word, for all purposes," he said, "cannot exist; but property in that word, as applied by way of stamp upon a stick of liquorice, does exist the moment the liquorice goes into the market so stamped, and obtains acceptance and reputation in the market, whereby the stamp gets currency as an indication of superior quality, or of some other circumstances that render the article so stamped acceptable to the public."

The present Lord Chancellor (1872), when Vice-Chancellor Wood, fully explained this principle in a case where a manufacturer claimed a right of trade-mark in certain numbers. His Honour said: "This Court has taken upon itself to protect a man in the use of a certain trade-mark as applied to a particular description of article. He has no property in that mark *per se*, any more than in any other fanciful denomination he may assume for his own private use otherwise than with reference to his trade. If he does not carry on a trade in iron, but carries on a trade in linen, and stamps a lion on his linen, another person may stamp a lion on iron; but when he has appropriated a mark to a particular species of goods, and caused his goods to circulate with this mark upon them, the Court has said that no one shall be at liberty to defraud that man by using that mark, and passing off goods of his manufacture as being the goods of the owner of that mark. And inasmuch as the Court protects the owner of the mark, he is entitled to authorise another, when he hands over his business to him, to place that mark on his goods. That is a right which, being protected by this Court, may be disposed of for value, may be bought and sold, and is therefore in that sense of the word property. The same may be said of a singer's voice. A singer may dispose of his voice by contract to one person, and the Court will prevent his disposing of that voice to another. The voice is in that sense property. Then, is not a man's name as strong an instance of trade-mark as can be suggested, subject only to this inconvenience, that if a Mr. Jones or a Mr. Brown relies on his name, he may find it a very inadequate security, because there may be several other manufacturers of the same name? But there is no evidence before me that any other person than the plaintiff has ever been heard of as manufacturing Ainsworth's Thread, and therefore 'Ainsworth's Thread' is as good a mark as 'Anchor Thread,' 'Lion Thread,' or any other which may be described by a particular name. The use, therefore, of the name of another manufacturer, whether done scienter or not, is an interference with his business, which this Court will interpose to prevent, on the ground that the defendant is endeavouring to pass off the goods of his own, or somebody else's manufacture, as the manufacture of the plaintiff."

The property in a name was carefully considered in the case of the *Belgravia* magazine, where the question was raised whether property of the character which is held in a trade-mark can be acquired in a name *before* the vendible articles bearing the name have been put upon the market for the purpose of sale. Advertisements of the title of the magazine had been issued extensively; and an attempt being made to use the name for a rival publication, the Court held that the persons issuing the advertisements had a trade-mark property in the name before publication.

The famous Reading sauce also affords a good illustration of this part of the subject. In the case of Cocks *v.* Chandler, the property in the use of the word "original" was largely discussed. In that instance it was urged that the word "original" is not like the word "chlorodyne" or "excelsior," and that a person could not be enjoined from stating, "I am the original inventor of the Reading Sauce," because, if originality consisted in having invented it only the day before, anybody may be an original inventor. It was there explained by the same judge whom we have already quoted (Lord Romilly), that if the person who uses the word is not the original inventor, then the word "original" is worth nothing. It is only in the character of being the first inventor that any person is entitled to the use of that word.

Having been dealing with the adoption of the same trade-mark by rival traders, we must now refer to cases of similarity. The general principles were laid down by the Lord Chancellor in the case of Seixo *v.* Provezende—that no trader can adopt a

trade-mark so resembling that of another trader, that persons purchasing with ordinary caution are likely to be misled, though they would not be misled if they saw the two trade-marks side by side; nor can a trader, even with some claim to the mark or name, adopt a trade-mark which will cause his goods to bear the same name in the market as those of a rival trader. But in these cases, as the Lord Chancellor remarked, questions of considerable nicety may arise as to whether the mark adopted by one trader is or is not the same as that previously used by another trader, complaining of its illegal use; "and," he added, "it is hardly necessary to say that, in order to entitle a party to relief, it is by no means necessary that there should be absolute identity. What degree of resemblance is necessary from the nature of things, is a matter incapable of definition *à priori*. All that courts of justice can do, is to say that no trader can adopt a trade-mark so closely resembling that of a rival, that ordinary purchasers, purchasing with ordinary caution, are likely to be misled."

We will now proceed to consider generally how a right of property in a trade-mark can be acquired so as to entitle its possessor to restrain interference with it. In a case to which we have already referred, Lord Romilly said: "The property which a manufacturer acquires in a trade-mark by the adoption of the use of it, is of a very peculiar nature." In an old case Lord Hardwicke doubted whether he could grant an injunction to restrain the use of a certain stamp upon cards, and that eminent judge is reported to have said: "Every particular trader has some particular mark or stamp; but I do not know of any instance of granting an injunction here to restrain one trader from using the same mark with another, and I think it would be of mischievous consequence to do it." Lord Romilly (the Master of the Rolls) discussed all Lord Hardwicke's reasons for his conclusions, and said, "It must be now conceded that some property exists in the use of a trade-mark, which at present is sufficient to support an action or maintain an injunction." He then proceeds thus:—

"It is clear, from a variety of decided cases, that a manufacturer who has originally stamped his goods with a particular brand, has a property in his mark at law, and can sustain an action for damages for the use of it by another. It is also clear that courts of equity will restrain the use of it by another person. It has sometimes been supposed that a manufacturer can only acquire such a property in a trade-mark as will enable him to sue for an injunction against the piracy of it by others, by his having enjoyed so long and continued a use of it as is sufficient to give it reputation in the market where such goods are sold. But I entertain great doubt as to the correctness of that view of the law. The interference of a court of equity cannot, it appears to me, depend upon the length of time the manufacturer has used it. If the brand or mark be an old one formerly used, but since discontinued, the former proprietor undoubtedly cannot retain such a property in it, or prevent others from using it. But, provided it has been originally adopted by a manufacturer, and has been continuously and still is used by him to denote his own goods, when brought in the market, and offered for sale there, I apprehend, although the mark may not have been adopted a week, and may not have acquired any reputation in the market, his neighbours cannot use that mark. Were it otherwise, and were the question to depend entirely on the time the mark had been used, or the reputation of it had been acquired, a very difficult, if not an insoluble inquiry would have to be opened in every case, namely, whether the mark had acquired in the market a distinctive character, denoting the goods of the person who first used it? The adoption of it by another is proof that he considers that at that time it is likely to become beneficial. If the manufacturer who first used it were not protected from the earliest moment, it is obvious that malicious and pertinacious rivals might prevent him from ever acquiring any distinctive mark or brand to denote his goods in the market, by adopting his mark, however varied, immediately after its adoption or change by the person who has originally used it. That evil would not be obviated by his putting his name in full, for if the name of the manufacturer was a common one, it would be difficult for him to point out to the public what goods were or were not manufactured by him. Those observations, in my opinion, apply to brands and marks generally; but it is essential to point out the distinction that exists between two different sorts of marks which I have already noticed—viz., the marks that denote the place where the goods are manufactured, and nothing more, and those which, on the other hand, denote the person who manufactured the marked goods, and nothing more." The learned judge then referred to a case in which the mark was the letters "M. C." branded on tin plates, made at certain works at Caermarthen. The letters had been adopted and used for a long series of years at those works, although carried on by different persons who succeeded each other. One of the lessees of those works, who had used the brand while he occupied the works, was held not to be entitled to restrain his successors from using the same brand. Lord Cottenham seems to have considered that the letters "M. C." denoted tin plates made at the works in question, and not those made by the plaintiff at any other place. "Assuming that to be so," remarks the Master of the Rolls, "then I apprehend that the mark or brand which denotes goods manufactured at a particular place may be, and probably would be, sold with the works themselves, and the mark would be as it were attached to the spot, to denote which it was first adopted, and which might possess peculiar local advantages for the manufacture of the article." We see clearly, therefore, the nature of the two classes of trade-marks, the one purely personal, the other purely local, and it will have been seen that the former attaches to the person so as to give the proprietor a right independent of locality, whilst the latter, as lawyers say, "runs with the land." Then the trade-mark must be honest, and applied to property of a specific kind. In the great case of the Leather Cloth Company against the American Leather Cloth Company, Lord Westbury said, "Where any symbol or label claimed as a trade-mark is so constructed or worded as to make or contain a distinct assertion which is false, I think no property can be claimed in it; or in other words, the right to the exclusive use of it cannot be protected." And as to the application of the symbols, his lordship said: "Property in a trade-mark is the right to the exclusive use of some mark, name, or symbol, in connection with a particular manufacture or vendible commodity; consequently the use of the same mark in connection with a different article is not an infringement of such right of property."

Before closing our consideration of the question of property, we must look at it very briefly, as it exists in partners and assignees. We have already shown that where the trade-mark consists of the name of a place, it passes from lessee to lessee without any assignment. But where the trade-mark is merely personal, as in the name of a person, or a title, design, or symbol, it can only pass by assignment. It was once doubted whether there could be any parting with the right to use a trade-mark, but that is now quite settled. This being so, another question arose—namely, how far, the trade-mark being parted with, others besides the purchasers are left in possession of it. And the principle established is this:—Although a trade-mark may include the name of a firm, the sale of that trade-mark will not preclude the purchasers of the business from using the name of the firm. But as regards a partnership—on a sale of a trade-mark, which is simply a design or symbol, it is lost as property to every member of the partnership. Several parties may be entitled to use a trade-mark, and wherever this is the case, a court of equity will use its power to protect them all.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLI.—SIR ISAAC NEWTON.

BY JAMES GRANT.

THIS illustrious philosopher was born on the 25th of December, 1642, in the manor-house of Woolsthorp, in the parish of Colsterworth, in Lincolnshire. Recent researches have proved that the family of this glory of his country and of his race came originally, during the reign of James VI., from Scotland, where the name is one of great antiquity. In the list of persons accused of treason in the records of the Scottish Parliament in 1568, appears William Newton of that ilk. His estate of Newton was in the constabulary of Haddington, and was bestowed upon a William Newton so early as the reign of Robert II., prior to whose time it belonged to the Swintons; but at the present time, there are upwards of sixty places in Scotland which bear the name of Newton.

Isaac was an only and posthumous child, his father having died a few months before his birth, in his thirty-sixth year. In 1646 his mother married a second husband, named Barnabas Smith, minister of North Witham, and her son was then left at his paternal estate in charge of her mother, who first placed him at a small day-school in the village of Skillington, from whence he was removed to another at Stoke, and in his twelfth year he was sent to the grammar-school of Grantham. In the house of Mr. Clark, an apothecary with whom he was boarded, the various chemical operations which he saw are supposed to have first awakened a taste for philosophical experiment and investigation in his youthful mind; and next a genius for mechanical inventions began to manifest itself in the construction of several curious pieces of workmanship, such as a clock and mill that went by water, and a carriage in which he could wheel himself round the room.

Geometry he studied deeply, making his way through the Elements of Euclid with such ease that he speedily became master of them. He remained at Grantham till the death of his stepfather in 1656, when his mother took him home to Woolsthorp, with the intention that he should superintend the farming of the property, and that he might lead the quiet life then led by English country gentlemen, after the storm of the great Civil War. But an occupation so humble had no attraction for Newton, and when, accompanied by a trusty servant, he was wont to attend the Grantham market to dispose of the farm produce, he used to leave the latter to attend the sale, while he seated himself book in hand by the wayside, or repaired to his old quarters at the apothecary's, where he would shut himself up among the works of the learned. Convinced at last that he would never make a good farmer, his mother wisely permitted him to follow the tenor of his own way.

Returning for nine months to the grammar-school of Grantham, at the expiration of that period, in June, 1660, a month after the restoration of Charles II., he proceeded to Trinity College, Cambridge. He was then in his eighteenth year.

There he applied himself to his studies, and especially to mathematical science with wonderful ardour, and though the statement may almost seem incredible, he appears actually to have completed all the splendid studies which have rendered his name immortal, within the *first* six years of his academical course. But then, says a writer, "there may have been minds as happily constituted as his for the cultivation of pure mathematical science; there may have been minds as happily constituted for the cultivation of science purely experimental; but *in no other mind* have the demonstrative faculty and the inductive faculty co-existed in such supreme excellence and perfect harmony."

In 1664 he purchased a prism for the purpose of trying some experiments suggested by a work of René Descartes; and the investigations upon which he thus entered, led him gradually to his great discovery of the composition of light, and the unequal refrangibility of the different sorts of rays, the doctrine from which nearly the whole of modern optical science is derived. Somewhere about the year 1666 he had invented his new instrument for calculation, the method of fluxions, that proud auxiliary to which physical science in so many departments owes its triumphs, and without which it would have been comparatively helpless; and it was in the same year that, having retired to Woolsthorp to avoid the plague which then raged at Cambridge, he was, while sitting in his mother's garden, first impressed with the theory of universal gravitation, by the simple incident of an apple dropping from a branch to the ground, from a tree that was only destroyed by the wind about 1830.

Concerning this popular anecdote, Brewster says (in his "Life of Newton"), that as it is mentioned neither by Dr. Stukely nor by Mr. Conduit, he did not feel himself at liberty to adopt it. We are told, however, that he immediately entered into the calculations necessary to verify the hypothesis he had formed, and would then have established its truth, had he possessed accurate measurement of all the distances to be considered; but being misled by incorrect statements, which prevented the result of his investigation from being what it ought to have been, it was not until some sixteen years after that, with rectified data, he resumed it, and brought it to a triumphant conclusion. Prior to this, in 1665, he had taken his degree of B.A., become a junior Fellow of the College a year subsequently, and graduated as M.A. in 1668, and in the same year obtained a senior Fellowship.

Dr. Barrow having resigned the chair of Mathematics, and accepted that of Divinity in 1669, Newton became his successor, and in January, 1672, was elected a Fellow of the Royal Society, to the *Transactions* of which he immediately began to contribute, and his papers on optics speedily drew upon him the attention of all the learned in Europe; but these, and other essays, involved him in many troublesome quarrels and literary controversies, which proved exceedingly distressing to one of a disposition so amiable, placid, and sensitive.

"I blame my own imprudence," he says passionately and regretfully, in one of his letters, "for parting with so real a blessing as peace, to run after a shadow!"

At last, he requested Oldenburg, the secretary of the society, to prevent, so far as he could, the appearance of any objections or philosophical letters that might be sent respecting his discoveries. He was also extremely averse to the publication of his "Principia," the grand disclosure of his philosophy of the universe, when the Society first urged permission to print it.

"Philosophy," he wrote to Dr. Halley, "is such an impertinent and litigious lady, that a man had as good be engaged in lawsuits as have to do with her." Eventually he yielded, and the work appeared in May, 1687. In this year he distinguished himself by his defence of the privileges of the University, against certain arbitrary attempts of James II. The Vice-Chancellor, and eight delegates elected by the Senate, had to appear before the formidable Ecclesiastical Commission; and one of those eight was Isaac Newton. "He was," says Macaulay, "the steady friend of civil liberty and of the Protestant religion; but his habits by no means fitted him for the conflicts of active life. He therefore stood modestly among the delegates, and left to men more versed in practical business the task of pleading the cause of his beloved University."

His activity, however, caused him to be returned as M.P. for it, in the year of the Revolution, and we are told that "among the crowd of silent members appeared the majestic forehead and pensive face of Isaac Newton: he sat there in his modest quietness, the unobtrusive but unflinching friend of civil and religious freedom." In 1690 he was one of those who voted for Sir Robert Sawyer at Cambridge, a fact which justifies us in believing that he had begun to see the headstrong and revengeful spirit of his own party, the Whigs, with disapprobation and concern. In 1695 he began also to take part in the discussion on the currency, and held many conferences on that important subject with Somers, Montague, and Locke; and in 1696 he was appointed from the office of Warden to that of Master of the Mint in England, an office then worth £1,500 per annum; and there his ability, industry, and strict uprightness produced a complete revolution throughout the department which was under his direction, though Pope writes cynically that Newton, "though so deep in algebra and fluxions, could not make up a common account; and whilst he was Master of the Mint, used to get somebody to make up the accounts for him."

He now relinquished the teaching of his class at Cambridge to Mr. Whiston, to whom he gave all the emoluments, and in 1703 he resigned his chair.

His residence in London was in St. Martin's Street, Leicester Fields, and after him it was long occupied by Dr. Burney, the eminent musician and historian of music. In the *Gentleman's Magazine* for 1814, it is described as a single building of six storeys in height; with "kitchen, parlour, first and second floors, garrets, and an *observatory*. Plan: passage to stairs on the right; on the left, rooms two deep. Elevation: between each floor plain strings, general cornice destroyed, a modern parapet, doorway, plain side pilasters, with scrolls, foliage and rich foliage: the dormer windows have pediments, the centre one a semi." And there, in that now squalid quarter of London, the great philosopher was living when he was again elected, in 1701, member for the University of Cambridge, defeating Hammond, who had been discovered at the famous supper in the Blue Posts Inn, and defeating him by a vast majority.

In 1703 he was elected President of the Royal Society, and not until the subsequent year—so much did he dread literary and scientific controversy—would he permit the publication of his work on "Optics." This was two years after the death of one of his most pertinacious tormentors, Hooke, who, while he lived, had almost regularly either contested the truth of every dis-

covery Newton announced, or went still further, and claimed it as his own. Newton was annually elected President of the Royal Society while he lived.

From Queen Anne, in 1705, he received the honour of knighthood, and the remainder of his life, save when engaged in the duties of his office, was spent, as the previous portion of it had been, in constant study, almost every department of science and of human knowledge receiving in its turn some new light from his singularly gifted intellect.

Newton died at his new home in Orbell's Buildings (afterwards called Pitt's Buildings), Kensington, on the morning of Monday, the 20th of March, 1727, in the eighty-fifth year of his age, and a short time before his death he is said to have uttered this memorable sentiment :—

"I do not know what we appear to the world; but to myself I seem only to have been like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

"What a lesson to the vanity and presumption of philosophers!" exclaims Sir David Brewster; "to those especially who have never even found the smoother pebble or the prettier shell! What a preparation for the latest inquiries, and the last views of the decaying spirit, for those inspired doctrines which can alone throw a light over the dark ocean of undiscovered truth!"

His monument in Westminster Abbey stands on the north side of the entrance into the choir, and not far from it is that of Earl Stanhope.

MINING AND QUARRYING.—XXXIV.

BY GEORGE GLADSTONE, F.C.S.

MANGANESE.

DISTRIBUTION — ORES — VARIOUS OXIDES — QUANTITATIVE ESTIMATION—USES—GLASS-MAKING—BLEACHING-POWDER DYEING—DISINFECTANTS.

ALTHOUGH manganese as a metal is only known to the curious, its ores have a wide distribution, and constitute a very important branch of the mining industry of this country. Notwithstanding, it is only within the last 100 years or so that the ores have received any attention at all, and till after the close of the last century two or three mines in a limited district in Devonshire supplied the entire consumption of the United Kingdom. It is only since it has been employed in the manufacture of bleaching-powder, that the great demand for it has led to its being vigorously wrought. Devonshire alone now supplies some 5,000 tons of ore annually, but this is not one-seventh of the present consumption of the country. In addition to this, Cornwall supplies a good deal of ore, principally from the neighbourhood of Launceston; it is also found in considerable quantity in North Wales, Somersetshire, and Warwickshire, as well as in Aberdeenshire, and in Wicklow and other parts of Ireland.

In Devonshire the ores generally occur in the rocks of the Carboniferous and Devonian age, and both here and in Cornwall they are much associated with trappean rocks, though it seldom happens that they are found in the immediate presence of granite or elvan dykes. The localities most favourable, therefore, for tin and copper are unlikely to yield manganese, and the principal mines of this ore will be found to surround the granite region of Dartmoor in all directions, but at some little distance from the igneous rocks. The ore very commonly occurs in bunches, the best being usually contiguous to the trap, but sometimes rich deposits are found in the red sandstones undisturbed by any eruptive rocks; and at others it is found in association with hæmatite iron ore, either as branches from the band of iron ore, or as forming one wall of the lode, with hæmatite for the other.

The prevailing ore is called by mineralogists pyrolusite, which is the peroxide of manganese (MnO_2), generally more or less mixed with oxide of iron, silica, alumina, etc.; containing when separated from the other ingredients nearly two-thirds of manganese to one-third of oxygen. The exact proportions are 63·2 of the one to 36·8 of the other. It is often called the black oxide, on account of its dark colour, though more strictly it should be termed brown. Psilomelanite and braunite also occur in quantity in some places; they are the hydrated peroxide and the sesquioxide of manganese. The mines in Devonshire are usually very shallow, so that the ores are generally brought to surface by means of a common hand-whim, horse-power even being seldom required. Wad is the common name of an inferior ore, also a hydrated peroxide, which is obtained in large quantities, sometimes massive, and at other times forming a coating on other minerals. It is extensively used in the production of chlorine.

Manganese ores occur on a very extensive scale in some parts of Germany, especially in Hesse, and the districts of the Thuringerwald and Hartz. During the last fifteen years, however, a considerable proportion of our foreign supplies have come from Spain, as some of the mines in that country are favourably situated for shipping their produce; the ores are rich, and are found in pockets in a schistose rock. Austria, Italy, France, Sweden, Canada, and the United States of America may also be enumerated as sources of supply in case of need.

The ores of manganese may readily be detected by the fine red colour of permanganic acid, and the green displayed by the manganates. Thus if the substance to be tested is fused with carbonate of soda or potash, the manganate of the respective substances will be formed, and the product will be of a decided green colour. Again, if the manganate of potash is dissolved in a very small quantity of cold water, so that the solution shall be as strong as possible, it will appear a dark green, but as water is added to weaken the solution permanganic acid will be produced, and the green will gradually turn to a bright red.

The chemical combinations which it is especially important to bear in mind are the following :—

Protoxide or manganous oxide . . .	MnO.
Sesquioxide or manganic oxide . . .	Mn_2O_3.
Peroxide or black oxide	MnO_2.
Manganoso-manganic oxide or red oxide . .	MnO,Mn_2O_3.

In estimating the quantity of manganese in any particular ore, it is usual to convert it into the last-named, or red oxide. If no other metals are present in the specimen the process is a simple one. After being weighed, it is first dissolved up and then boiled, after which an excess of carbonate of soda is added which will cause the whole of the manganese in the solution to be precipitated as a carbonate. This is collected on a filter, well washed with boiling water, and lastly ignited in a crucible until it no longer decreases in weight. The result will be the red oxide, a comparison of which with the original weight of the article operated upon will give the per-centage of manganese in the ore, the atomic weight of the metal being 55.

Another method very commonly adopted in valuing the ore consists in weighing out a certain quantity of it, and then treating it with hydrochloric acid, by which means it is converted into chloride of manganese, water, and free chlorine. The especial significance of this mode of dealing with it will become more apparent when we come to speak of the chief use of this substance in the arts—the manufacture of bleaching-powder. The chlorine gas is absorbed as fast as it is generated by passing it into a solution of potash. A test solution of arsenious acid is then made of a known strength, and this is coloured blue with a little indigo, and put into a graduated tube. The blue liquid is then poured very gradually into the potash solution, which deprives the indigo of its colour as long as there is any chlorine available. The moment that the indigo is seen to retain its colour it is known that the arsenious acid has exhausted the supply of free chlorine, by their conversion into arsenic and hydrochloric acids; and the quantity of the original acid solution being read off on the graduated tube, it is easy to calculate the amount of chlorine that was originally in the potash solution, two atoms of chlorine being to one of the peroxide of manganese as 71 is to 87, and from that the proportion of manganese in the ore.

Manganese, until a very recent period, was scarcely used except by the glass-maker, who employed it for the purpose of depriving glass of the greenish tint which it nearly always acquires, in a greater or less degree, from the presence of minute quantities of iron in the materials from which the glass is made. This slight colour is the more objectionable now that very thick glass is so largely used, and it is therefore more than ever necessary for this purpose. Of course none but the very purest qualities of ore will suit the glass-makers, and they must be especially cautious that it contains no iron. Wad nearly always

has some of the latter metal associated with it; but pyrolusite may be obtained in some places altogether free from this objectionable ingredient, and it is this description of ore which is therefore almost exclusively used by them.

In making bleaching-powder or chloride of lime, the old plan was to treat with sulphuric acid the oxide of manganese mixed with common salt (the chloride of sodium), in a still made of strong sheet-lead. The accompanying diagram (Fig. 1) will show the arrangements necessary for the purpose. The ingredients are contained in the receptacle A, which is entirely surrounded by an outside shell B, which is dome-shaped above, a sufficient space being left between A and B for steam to pass round. The receptacle is provided with a rotatory stirrer, worked by a rod which passes out through the top of the dome. The manganese ore and the salt are dropped in through the opening C, and the acid is poured in through the twisted funnel D. The steam, which is commonly employed as the source of heat, is introduced at E, the pipe F on the opposite side being merely the channel through which the charge is withdrawn after it is exhausted. All the openings being made quite fast, the steam is turned on, and the temperature kept up at about 180° Fahrenheit, the mixture in A being well stirred until chlorine ceases to be evolved. As the gas is set free it passes off through the pipe G into the receiver, where it is combined with lime in order to make bleaching-powder. The latter part of the process has, however, nothing to do with the subject of the present article.

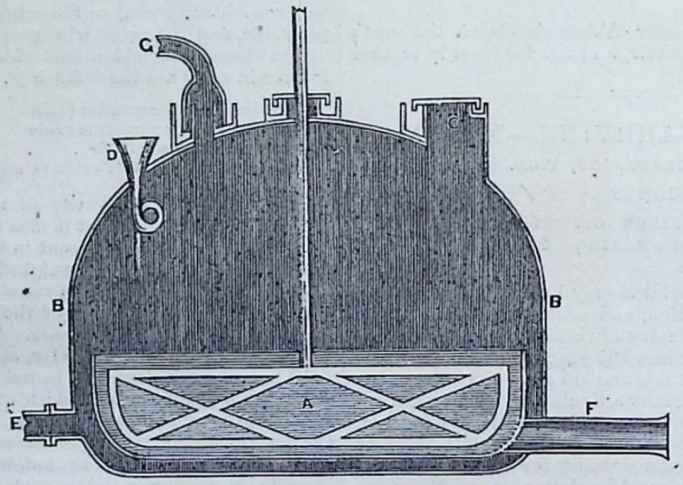


Fig. 1.—STILL USED IN MAKING BLEACHING-POWDER.

A much cheaper mode of producing the chlorine gas required for this purpose is to digest the manganese ore with the waste acid produced in the alkali works by the decomposition of common salt, in the manufacture of sulphate of soda. The chlorine vapours given off in the soda manufacture used to be a source of great annoyance to the neighbourhood, and measures had to be taken to abate the nuisance. The result was that apparatus was designed for the economical condensation of the gases into hydrochloric acid, which is now produced at such a price, that the cost of bleaching-powder has been reduced to about one-third of what it was when salt and sulphuric acid were employed. As already stated, the result of the action of hydrochloric acid upon the manganese ore is to convert the oxide into a chloride, setting free gaseous chlorine at the same time. The theory of the process may be best illustrated by the following equations, which show the proportions of hydrochloric acid to one equivalent of some of the various oxides which may be conveniently used for the purpose:—

Black oxide . $MnO_2 + 4HCl = MnCl_2 + 2H_2O + 2Cl.$
Sesquioxide . $Mn_2O_3 + 6HCl = 2MnCl_2 + 3H_2O + 2Cl.$
Red oxide . $Mn_3O_4 + 8HCl = 3MnCl_2 + 4H_2O + 2Cl.$

It will be seen that the proportion of hydrochloric acid required varies in each case, though the proportion of chlorine evolved is constant, the increase being in the chloride of manganese. This naturally points to the black oxide as the most appropriate for the purpose.

For some years after the introduction of this process on a manufacturing scale, the chloride of manganese was treated as a waste product, and was thrown aside. Various plans have been proposed for utilising this material, and some have been found practically successful. At the great works of the Messrs. Tennant, of Glasgow, the chloride is converted into the carbonate of manganese by heating it under pressure with chalk in an iron boiler, chloride of calcium being formed at the same time; the latter substance is dissolved out, and the carbonate of manganese dried on iron trays, the temperature of which is gradually raised until the carbonic acid is driven off, and the manganese is left behind in the state of peroxide. By this plan the same material can be used over and over again, rendering fresh supplies of the mineral almost unnecessary.

The chloride itself, when properly purified, is used as a brown dye. A neutral solution free from iron may be prepared by digesting the crude article along with powdered chalk, by which means the sesquioxide of iron which is generally present will be decomposed.

The sulphate is, however, more generally used. It is made by roasting the peroxide with a little powdered charcoal, so as to reduce it to the protoxide, MnO; and this is next converted into the sulphate by treating it with dilute sulphuric acid. The iron which is commonly associated with it is got rid of by evaporating down the solution, and then roasting the residue, by which means the iron is converted into an insoluble salt; the pure sulphate of manganese being separated therefrom by dissolving it out with water. On evaporating down the solution the salt will crystallise out. A shorter process is to mix the peroxide of manganese with sulphate of iron, and roast the two together, producing at one operation the sesquisulphate of iron and the sulphate of manganese, which are then separated as before by dissolving out the latter with water.

In dyeing with manganese sulphate, the cloth is first dipped in a solution of this salt for a time, and then treated with an alkali, which combines with the sulphur and leaves the manganese free to take up oxygen. It thus becomes gradually converted into the peroxide, or black oxide, as it is commonly called, but which is really a brown, and appears of that colour when used in small quantities. The raising of it from the protoxide to the peroxide is expedited by afterwards dipping the cloth in a chloride of lime solution.

The acetate of manganese is also used for a similar purpose, and in a similar manner. It is made from the sulphate by adding acetate of lead, in the proportion of seven parts of the latter to four of the former, both salts being first dissolved in water. The colour is brought out by the use of chloride of lime only.

An application of manganese of some considerable importance, both in a social and commercial aspect, is due to the instability of the manganates and permanganates of the alkalis. The solutions of the alkaline permanganates are of a deep purple-red colour. They are all reduced by the action of organic compounds to a colourless state, so that water which is rendered impure by the presence of any nitrogenous substance can be at once tested by dropping it gradually into one of these solutions. On account of their value as oxidising agents, and the rapidity with which they act upon organic matter, they are largely employed as disinfectants in sick chambers, and may also be applied with advantage to putrid sores and wounds, as well as to tainted meat. The permanganate of potassium, which is one of the combinations most usually adopted for such purposes, is made by igniting one volume of peroxide of manganese with one of hydrate of potassium, or 1·8 of nitrate of potassium. The product is then dissolved in water, decanted and evaporated, rapidly at first, until the red crystals of the permanganate begin to appear, and then gradually till the operation is complete.

The value of manganese as an oxidising agent in the manufacture of iron and steel has been described already in detail when treating of those operations, and the reader may be referred to Article XIV. of this series (Vol. III., page 30), where the composition and uses of spiegeleisen and also the alloy called ferro-manganese are fully considered.

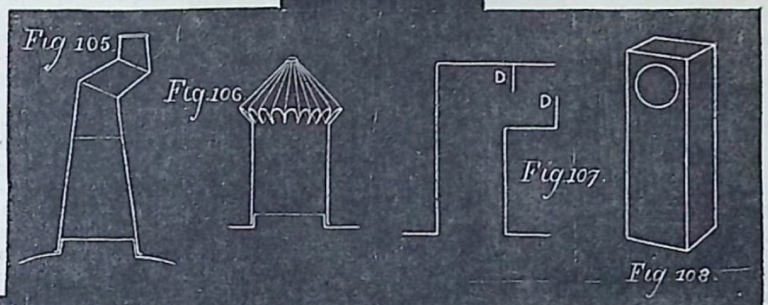
OPTICAL INSTRUMENTS.—XXIII.

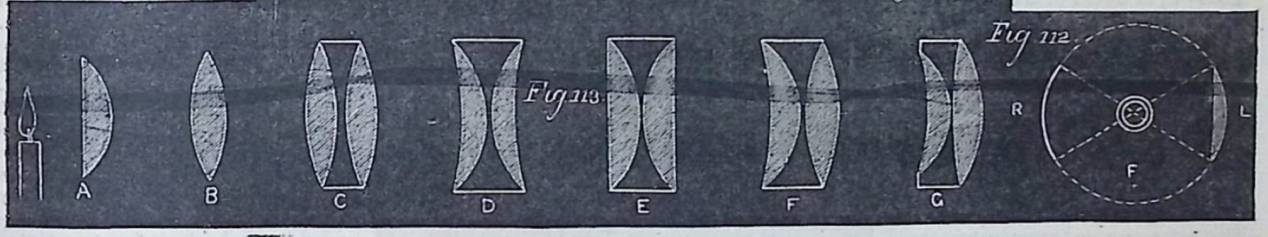
BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN (*continued*).

The Principles of Lantern Construction.—It will be well at this stage to consider the most important points in lantern construction, according to modern experience. The *body*, made either of metal or wood, is arranged so as to prevent any rays from "the source of light" escaping into the room where the views are exhibited, for any extraneous light would detract from the brilliancy of their colours and sharpness of their outlines, especially if the source of light be a weak one, as in the case of the Argand burner, greater latitude as to this condition being allowable if the lantern is to be employed for the lime-light or electric light only. The body may be square or round, but is usually oblong. The height is governed by the requirements of the source of light, being usually sufficiently high to allow the chimney of an Argand lamp, or the upper pole of an electric regulator, to stand beneath the *dome* or roof of the lantern, though if the oxy-hydrogen light only is required, then the body may be very squat, especially if portability be a matter for consideration. The *chimney*, employed for the double purpose of carrying off the smoke of a lamp and creating an "up-draught" for ventilation, must be placed immediately over, and central with, the chimney of any lamp when it is placed in focus with the condenser. The chimney as usually constructed is of the form shown in Fig. 105; but I consider its contracted shape very objectionable, as interfering with free ventilation. The cylindrical chimney employed in the old-fashioned lanterns, and modern instruments of large size, shown in Fig. 106, also hampers ventilation by the contracted nature of the gauffered cowl. A better arrangement, I found, was to make the chimney cylindrical, and of the form shown in Fig. 107, of equal diameter throughout its entire length. At first, for the purpose of cutting off the small amount of light reflected from the dead black surface of the inside of the chimney, I introduced two semi-circular diaphragms fixed as shown at D, D; but I found it better to dispense with these, so as to give an unimpeded current to secure perfect ventilation. Since then I have made the chimney on this principle, but square (Fig. 108), instead of cylindrical, for the purpose of economising space, by utilising the inside of the chimney for holding slides, in the manner hereafter to be described. The *floor* of the lantern is usually double, and pierced with a double series of non-corresponding air-holes on each side; but I found it advantageous to provide for a greater amount of air passing through the body of the lantern, either by large openings in the base of the lantern, or by slots an inch wide running along each side of the floor, when the body was made in wood. By thus introducing a larger and freer current of air through the lantern, I found that the tin linings usually added to the better class of bodies for the purpose of keeping the exterior wall cool to the touch, were quite unnecessary, as I could keep my hand on the top of a lantern made of a single thickness of tin, even after a powerful Argand lamp had been burning in it for some time, the metal being kept perfectly cool by the increased draughtway. The lamp is usually supported in a socket, A, and the lime-light jets on a slight rod B, fixed to a tin tray that slides into grooves in the floor of the body, as shown in Fig. 109. I prefer, however, to make the base of the lantern in wood, to allow of a solid mahogany slab, sliding in and out freely by groove-and-tongue fitting, being employed to carry the brass rod on which the lamp or jet is adjusted for focussing the light with the condenser, as shown in Fig. 110. Most lantern-workers must have experienced the difficulty of firmly clamping any form of burner or jet that has, through its length, much leverage, on to the thin adjusting rods usually attached to the lamp-trays. To overcome this, I tried larger rods and powerful screw-ring clamps, but with slight advantage, when I thought of filing away the side of the supporting rod R, opposite the thumb-screw, S, so that two sharp edges were left to bite on the adjusting clamp-tube, T, as shown in Fig. 111, and the defect was perfectly mastered. The clamp-ring attached to each form of lamp should have the inner lining tube projecting upwards to such a height that it can carry the reflector, so that lamp and reflector may be adjusted at the same time, as in Fig. 90, page 365, Vol. III. The adaptation of the kaleidoscope to the lantern renders an adjustment for the lamp as well as the jets imperative.

Fig. 111.





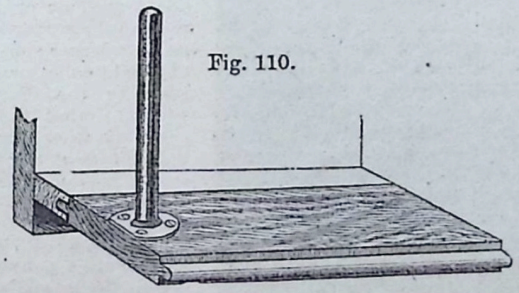


Fig. 110.

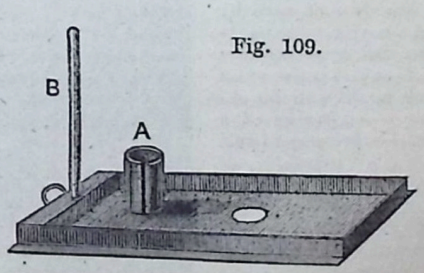


Fig. 109.

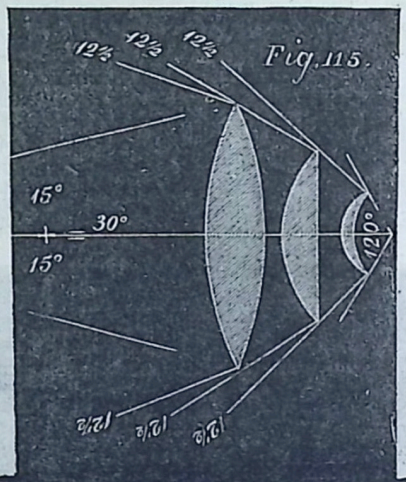
The *sources of light* for the magic lantern have been fully described in the previous series of articles on "Optical Instruments" in Vol. III. of THE TECHNICAL EDUCATOR.

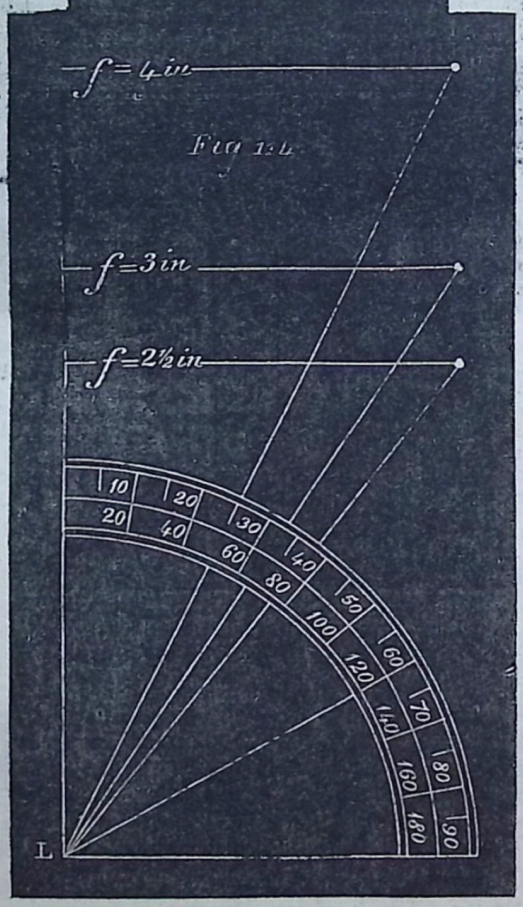
The *reflector* used in conjunction with lamps is usually made of plated copper; but as the plated surface readily tarnishes, and soon gets scratched with cleaning, I find it is preferable to employ concave glasses backed with pure silver deposited by Liebig's or Petitjean's processes, protected by a stout covering of electro-deposited copper, and supported by light metal arms fitted to an adjusting screw, in the manner

previously described (Fig. 90, page 365, Vol. III.). Such glass reflectors only require wiping just before use, and always retain a brilliant reflecting surface. Plated mirrors have been found to absorb half of the light they receive: such mirrors as I recommend reflect about 90 per cent. of the incident rays; while glasses backed with mercury reflect only about 65 per cent., and these are at least 20 per cent. better as to reflecting power than plated copper when new. The reflector must not subtend a greater angle from the centre of the flame than does the first lens of the condenser, or the rays from its margin would fall outside the edges of the lens. The best effect is attained when both subtend exactly the same angle, and the centre of the flame F coincides with the centre of curvature of both the reflector R and the lens L, as shown in Fig. 112, in which case both R and L should also be of the same diameter. As a rule, sufficient attention is not given to the form and focal length of the concave reflector in its relation to the condensing lens, and no provision is made for its proper adjustment; hence it often mars rather than adds to the even brilliancy of the field on the screen. In such instances a better effect would be produced by simply placing a disc of white paper or a flat white Dutch tile behind the flame, or, better still, a flat reflector made out of baked pipe-clay.

The *condenser* may be single, double, or triple, and its construction is framed with the view of picking up the greatest number of rays from the source of light, compatible with obtaining a flat field, free from all colour except at the extreme margin of the disc, when projected on a white screen in combination with a "power" of suitable focus. The latter proviso is very necessary, as a condenser with a short focus that may yield a most satisfactory result *per se*, or with a power of short focal length—say of 4½ inches—or of moderate focal length—say of 9 inches—may produce a dark spot in the centre of the field, if employed with a power of long focus—say of 16 inches. It is true we may lengthen the cone of rays by pushing the light nearer to the condenser, but then the cone becomes truncated, and does not come to an apex. A better result will be obtained by using a condenser of a focal length sufficiently long to suit the long focus of the "power."

The condensers in ordinary use are, the common "bull's-eye" or plano-convex, A (Fig. 113), the best position for which is with the plane face next to the light, while the usual focal length adopted is about 2½ inches. The double convex, B (Fig. 113), of about 2½ to 3 inches focal length, from 1½ up to 3 inches diameter, is used with small lanterns; beyond this size it is necessary to employ what is termed the "double condenser," the two previous forms being designated as "single condensers." The double condenser may be formed of two double-convex lenses of equal curvatures, as in C (Fig. 113), giving a combined focus of about 2½ inches focus, each element being of 5 inches focal length. This type may be varied by one lens being thinner, and consequently of greater focal length than the other, or both elements may be "crossed lenses:" in any case it is well suited for Argand burners with large flames, but not for points of light, as when the lime-light or electric light is to be employed; further, this combination is not efficient if over 3½ inches diameter. For flame or point of light a pair of meniscus lenses are used by some makers, as shown in D (Fig. 113), but a pair of plano-convex lenses, shown at E (Fig. 113), form a better and cheaper arrangement, that gives a very flat field. Perhaps the best form of double condenser, and one that has been almost universally adopted by the wholesale lantern-makers, is that represented at F (Fig. 113). This consists of a deep meniscus and a double-convex lens, the combined focus being 3½ inches in old forms, or as short as 2¾ inches focal length (measured from the centre of the combination) in condensers of recent manufacture. This ought to be known as "Herschel's Condenser," having been described by that eminent philosopher in the *Philosophical Transactions of the Royal Society* for 1821, as giving the best curves for crown glass, to correct spherical aberration only, aberration of colour being left uncorrected, as the combination was only intended to act as a very powerful burning glass, for which it answered most perfectly. Its proper position in relation to the source of light is shown in F (Fig. 113), but some lantern-makers mount this combination in a reversed position, through a want of optical knowledge of the aims of the arrangement, and a desire to send out "something different" in aspect from that supplied by their brother makers. I have seen this form designated in some catalogues of the optical dealers as "achromatic condensers," the very point of construction Sir John Herschel ignored. This form, as stated above, is now made of as short a "back focus" (that is, the distance at which parallel rays are brought to a focus, measuring from the edge of the meniscus lens) as 2½ inches; and G (Fig. 113), Gravett's condenser, is of a similar character, for it is a matter of the utmost importance to adopt such an arrangement as will pick up the greatest amount of light, as a condenser simply plays the part of a light-collector. Now it will be seen by the diagram shown in Fig. 114, that three condensers of *equal diameter*, say 4 inches, but of *different focal lengths*, say of 2½, 3, and 4 inches respectively, subtend from the point of light, L, the angles 76°, 66°, and 50°; consequently the condenser of 3 inches focus picks up 10° less light than one of 2½ inches focus, one of 4 inches focus 16° less light than a condenser of 3 inches focus, and 26° less light than one of 2½ inches focus: therefore, the shorter we can make the focus, the nearer we can get to the light, consequently the more light we should pick up, were we not limited by practical difficulties, such as the probable cracking of the lens when placed too close to an intense light, or the jet of ignited oxy-hydrogen gases being reflected backwards on to the lens if the lime-ball pits or cracks through being of inferior quality; which difficulties, to a certain extent, might probably be overcome by placing a plate of plane plate-glass between the light and condenser, and so arranged in the body of the lantern





that an up-draught of cool air should pass between the plate and condensing lens, so that if any breakage occurred it should be with the comparatively valueless plate of glass. Important as it is to seize upon all rays practically attainable when dealing with the lime-light, it is of still greater consideration when arranging the lantern for a weak source of light, such as the most powerful Argand must really be considered. Theoretically, it has been argued that nearly all the light given off from an Argand burner should be collected if placed in the centre of a globe, one hemisphere of which should consist of a reflector, the other hemisphere of a condensing lens or lenses. Though there is no difficulty in making a hemispherical reflector, there would be a great, if not an insurmountable difficulty, in constructing a hemispherical condenser that should be free from spherical aberration, and bring all the rays to a single focal point. In a little work on "The Magic Lantern," by Professor C. Tomlinson, of King's College, London, a lantern with a triple condenser is described, in connection with which it is stated (page 15): "Now supposing the first lens to subtend from the lamp an angle of 120°, it will intercept one-fourth of the whole light.* Each lens may bend the extreme rays which fall on its edges to 25°, so that the bending by all the three lenses may amount to 75°, thus converting the rays from diverging at 60° from the axis to converging 15° towards the axis, so that the extreme rays, after crossing in the centre of the smallest lens or object-glass, may diverge again at an angle of 15° from the axis, or 30° from each other." Not knowing of any arrangement that could include so great an angle as 120°, and perform as stated, I wrote to learn the name of the maker of the lantern figured in this work, which was published in 1854. In answer Professor Tomlinson wrote me, "The lantern figured and described in my little book *is a theoretical one*, and I cannot find that the plan has ever been adopted." Fig. 115 shows Tomlinson's triple condenser as described; but it will be seen that the refractive power of the combination is not sufficient to bring the rays parallel, much more to a converging point of 30° towards the axis.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Galletly, Curator, Industrial Museum, Edinburgh.

IV.—PROGRESS DURING THE EIGHTEENTH CENTURY—KINDS OF WOOL NOW USED.

From the beginning to nearly the close of the eighteenth century home-grown wool continued to be the only kind used in British factories, Spanish wool not being imported for manufacturing purposes before 1791. During that time the woollen trade remained, with the exception of one or two brief intervals, in a healthy state, but it did not make much progress. This is shown by the exports, which, according to M'Culloch, were, for an average of six years ending with 1789, of the annual value of £3,544,160, or only about £540,000 more than they amounted to in 1700. Notwithstanding the slight advance in the quantities of fabrics made, the eighteenth will ever be a remarkable century in the history of the textile industries, because then were invented all those wonderful machines which have since raised them to their present vast and still growing proportions. The first step in advance of the primitive apparatus, previously in use for thousands of years, was the invention of the "fly-shuttle," by Kay, in 1733. By this and other improvements in the loom, he at once doubled the quantity of cloth which a weaver could make in a given time; and these were first adopted by Yorkshire cloth-makers. Five years later came Paul's still more ingenious invention of drawing out cotton by rollers, afterwards adopted and carried out with great success by the energetic Arkwright. In 1764 Hargreaves constructed the "spinning jenny," in which he made a spinning-wheel turn many spindles instead of a single one. Crompton, in 1779, combined the advantages of Paul's rollers and Hargreaves' spinning frame into a single machine, which has since been called the "mule." During the seven years between 1785 and 1792 Cartwright matured his power-loom. Finally, leaving minor improvements out of account, Jacquard produced, in 1790, his celebrated apparatus, named after him, for weaving figured fabrics, which practically leaves the designer unlimited in his choice of pattern on the score of cost.

* A circle drawn on any globe with a radius of 60° encloses a fourth part of the surface of that globe.

Many naturalists consider that the sheep is more readily affected by changes in the condition of life than any other domestic animal. Wools greatly differing in their properties are, at all events, obtained from different breeds of sheep, and these are "indigenous to the soil, climate, and locality in which they graze." So thoroughly indeed are the several races adapted to a special set of conditions, "that a flock of heavy Lincolnshire and light Norfolk sheep which had been bred together in a large sheep-walk, part of which was low, rich, and moist, and another high and dry, when turned out regularly separated from each other." Sheep from a tropical climate, when brought to England, rarely live longer than two years, and when European breeds are sent to the tropics their fleeces quickly change their character, becoming coarse and hairy. Even in its native country the fine wool of the Merino sheep is said to be hard and coarse in the warm season after shearing time, and only to recover its soft quality when cold weather returns. The Down wools of England are much softer and cleaner on the rich clay districts of Kent and Sussex than on the sands of Norfolk or the chalk hills of Wiltshire, where they are somewhat harsh in the fibre.

As has been stated in an earlier paper, wools for commercial purposes are divided into *short-stapled* or *carding wools* used for woollen cloths, and *long-stapled* or *combing wools* used for worsted stuffs.

The British breeds of sheep yield wools which are classed indeed as long and short, or long and medium, but all, except a portion of the shorter kinds, are used for combing purposes. They are conveniently divided into two general classes:—

I. The *long-stapled wools*, which include the following:—(1) The *Lincoln*, obtained from what Youatt thinks may be considered the parent of the English long-woolled breeds, and which is, at least, a good type of our deep-grown wools; it has a long, bright, silky staple, which makes it well suited for lustre goods, in imitation of mohair and alpaca textiles; the value of this wool has much increased of late years. (2) The *Romney Marsh* wool, also obtained from an ancient breed; like the Lincoln, it is somewhat coarse, but long, lustrous, and adapted for the same kind of goods. (3) The *Leicester* wool, which is now much better than that obtained in former years; although finer than the Lincoln in the staple, it is not so soft and silky, yet still highly esteemed for combing purposes. (4) The *Cotswold* wool, which resembles the Leicester, but rather harsher: not much Cotswold is now obtained, as the pure breed has become scarce. (5) The *Highland* or *Black-faced* breed yields what is rather a wool of middle length than long, yet it is usually classed with the long-stapled wools. In quality it varies much, according to the care bestowed upon it; but its general use is confined to rugs, carpets, and Scotch blankets.

II. The *short* or *medium-stapled* wools, which are principally furnished by the different breeds of Downs. These all possess the same general characters, so that any differences which do exist are owing more to soil and climate than to any particular variety of breed. (1) The *South Down* is a short-stapled wool, fine in the hair, but slightly harsh and brittle, of which the longer qualities are combed—*i.e.*, prepared for worsted yarns—and the shorter for making flannels and light woollen goods. (2) The *Hampshire Down* only differs from the last in being usually longer in the staple and somewhat coarser; (3) the *Oxford Down* is still longer and coarser; while (4) the *Norfolk Down*, although often dirty, with sandy particles in certain districts, yields a fine, valuable wool, softer but not so strong as the pure South Down. (5) The *Shropshire Down* has a longer and more lustrous staple than any of the other Down breeds, and is increasing in importance. (6) *Cheviot wool* is derived from a valuable and hardy breed, now very widely diffused over Scotland and many parts of England. It is of medium length, fine-haired, and largely used for both worsted and woollen goods, fine cloths excepted. (7) *Welsh wool* has some of the fine qualities of the South Down, but has a hair-like texture and is deficient in the waved or spiral form, which gives a special value to high-class wools. Much of it is consumed in the manufacture of Welsh flannels and blankets. (8) *Shetland wool* is not unlike the Welsh in most of its properties, only it is much finer and softer. Its exceeding fineness is well seen in the beautifully-knitted shawls, veils, and the like, made by the peasantry of the islands.

For technical purposes fleeces are further divided into two classes, according to their age; thus, the fleeces shorn from sheep which have not previously been shorn as lambs, are

called *hogs* or *tegs*. Such fleeces are, as a rule, longer and more pointed and spiral in their staples than those clipped subsequently from the same sheep. This yearling wool accordingly possesses properties which suit it better for some kinds of goods than that obtained from older animals. Although not strictly adhered to, the term "hog" applies properly to the first shorn fleece of any long-stapled wool, and "teg" to a similar fleece of short-stapled wool. The other class of fleeces comprises those obtained from sheep in their second and subsequent years, called *wethers* or *ewes*. To good, healthy, sound fleeces more than one year old the term "wethers" is generally given; and "ewes" is applied, in the case of long-stapled wools, to the short, tender, inferior fleeces; while in the short-stapled wools it is applied to the shorter grown fleeces. In some districts along the south coast the farmers clip their lambs, in which case the fleece is called *shorn lambs' wool*. There is yet another description of wool known as *skin-wool*, which is obtained from sheep slaughtered for food. As this is obtained at all seasons of the year it varies much in character, even for the same breed of sheep.

Foreign and Colonial Wools.—The short-stapled wools properly so called—that is, those intended for the manufacture of the better qualities of woollen and for some of the finer kinds of worsted cloths—are now all imported, and, moreover, are all obtained from sheep sprung from the Merino stock. This famous breed, which has conferred great wealth on some of our colonies and other countries, as we shall presently see by some statistics, is a native of Spain. The animal is not prepossessing in appearance, being thickly covered with short wool full of yelk, which gathers a dirty crust, and often gives the fleece the appearance of being singed. Youatt, in his exhaustive book on "Sheep," after noticing that the fibre of Merino wool exceeds in fineness and in the number of serrations and curves that from any other sheep in the world, says, "that the excellency of the Merinos consists in the unexampled fineness and felting property of their wool, and in the weight of it yielded by each individual sheep; the closeness of that wool, and the luxuriance of the yelk, which enables them to support extremes of cold and wet quite as well as any other breed; the easiness with which they adapt themselves to every change of climate, and thrive, and retain, with common care, all their fineness of wool under a burning tropical sun and in the frozen regions of the north; an appetite which renders them apparently satisfied with the coarsest food; a quietness and patience, into whatever pasture they are turned, and a gentleness and tractableness not excelled in any other breed."

This statement is not strictly true as regards the effect of climate, because in warm countries like Spain the flocks are believed to preserve the fineness of their fleeces by feeding in the plains in winter and the mountains in summer, a custom which necessitates their wandering hundreds of miles twice in the year. There is, no doubt, even in Spain, a breed of *stationary* or non-migratory Merinos, which are said to yield wool equal in quality to the migratory ones, but they inhabit the pastures of the Guadarrama mountains; and in some countries of the Southern Hemisphere, where sheep of the Merino breed are now so plentiful, the depreciation of the wool caused by the vicissitudes of climate is so well marked that recourse is had to the importation of fresh Merinos from Europe, in order to preserve its quality. Spain, which in the beginning of the century was our great source of fine wool, now exports but little. For the last fifty or sixty years circumstances have not been favourable for the development of her industries; but it is believed that she has still large flocks of her precious Merinos, of which about 10,000,000 were in the country not very many years ago.

With respect to the production of fine wool in other European countries we find that the Merino breed was introduced into Saxony in 1765, where, with unremitting care and attention, they not only became perfectly naturalised, but in the course of years actually produced wool superior to the Spanish. Saxony wool has long been highly esteemed for the finest woollen cloths, for some kinds of ladies' shawls, and for other high-class goods. Silesian wool from Merino breeds is but little inferior to the finest Saxony. In the Austrian Empire, where Merinos were introduced in 1775, the first attempts to produce fine wool were not successful. Ultimately, however—and especially in Bohemia, Moravia, and Hungary—they were attended with complete success, and much of the wool now grown in these provinces is perhaps unrivalled in quality. In several large districts of Austria the cultivation of the sheep forms the chief source of wealth, the total number of all kinds in the country, as estimated a few years ago, being not less than 30,000,000. Russia is known to produce Merino wool little inferior to the best German, but in that vast empire almost every other kind and quality of wool is reared as well. The quantity Russia sends to Great Britain annually has much increased of late years, and in 1870 it reached the large amount of 6,000,000 lbs. This, too, must be a comparatively small portion of its exports, as most of the wool not consumed in Russia itself is sent to France. Russia in Europe contains about 70,000,000 sheep of all kinds, of which about one-fifth part are Merinos. France appears to be paying more attention than formerly to the culture of wool, and especially to Merino of the second quality. It exported 5,689,953 lbs. to Great Britain in 1870, while a few years back it sent none. France has at the present time about 30,000,000 sheep, of which about two-thirds are Merinos, either pure or crossed. Italy and Turkey are both considerable wool-producing countries, and the latter especially in this respect capable of great development.

In no country on the face of the globe has the success attending the introduction of Merino sheep been so absolutely astonishing as in Australia. Three rams and five ewes were taken out to that country in 1797 by Captain M'Arthur, and from these have sprung the vast number of this fine breed—now more than 40,000,000—whose fleeces, as shown in the table in the following page, yield more than one-half of all the wool imported into England. Australian wool is generally of regular fineness, elasticity, and strength. It bleaches pure white, is easily twisted, and will do equally well for carding or combing. The stronger sorts are now much used in England, France, and Germany for the fabrication of merino and other fine tissues for female wear; while the feebler kinds are used for carding purposes, in which case the felting process gives the cloths into which they are made sufficient strength. Next to Australia in importance, so far as British imports are concerned, stands South Africa. This country has made rapid progress of late years, and, like Australia, produces wool not much inferior to the finest German. Indeed, the perfection to which machinery has now been brought enables the manufacturer to produce, with these lower-priced colonial wools, goods which look as well as those made from the choicest German fleeces, except in some special fabrics. The wools of the Cape are less fine, but more soft and tender than those of Australia. They are also shorter in the staple, and therefore are mostly used for carding purposes.

Wool has of late years become an important article of export from India, but the supply appears to be falling off again. Most of it is of inferior quality, although it is stated in an Inland Revenue Report issued a few years ago that some of the valleys through which the tributaries of the Indus flow "supply grazing ground not to be surpassed in richness and suitableness in any part of the world. The population inhabiting them are chiefly pastoral, but, owing to sloth and ignorance, the wool they produce is but small in quantity, full of dirt, and ill-cared for in every way." Merino rams have been imported for the purpose of improving the breed, but not yet with much success. It is in Northern India where the finest wool in the world is obtained. This is the downy wool found next the skin below the thick coat of hair of the Thibetan goat, and from it the fine Cashmere shawls are made. It sells for about seven shillings per pound, or nearly double the price of the finest German wool.

In the region of South America watered by the La Plata and its tributaries, the increase in the production of fine wool since the first importation of Merinos, in 1826, has been, as in other countries of the Southern Hemisphere, very remarkable; scarcely less so, indeed, than in Australia itself, for the quantity exported from Buenos Ayres in 1866 amounted to 140,000,000 lbs. The wools of the province of that name are fine and soft, but generally wanting in strength, although those of the neighbouring provinces are inferior in quality. None of these wools are so much esteemed in England as they are in France and Belgium. Probably this is mainly due to the fact that they are, like the common wools grown in other parts of South America, much mixed with seeds and burrs, which are difficult to remove. The French, however, think it is partly due to prejudice. We

are indebted to South America for a peculiar kind of wool, furnished by a tribe of animals nearly allied to the camels, but also in some respects like the sheep. The best known of these are the alpaca, llama, vicuna, and guanaco, but only the first two are domesticated. They inhabit the high valleys of the Andes, in Peru, Chili, and Bolivia. The alpaca alone is reared for its wool, which is extremely fine, silky, of various colours, and usually from six to twelve inches long, but occasionally much longer. The llama, though mainly of service as a beast of burden, also yields wool, which, however, is coarse; while that obtained from the vicuna is much prized for its fineness. It is only about forty years since the wool of the alpaca tribe became an article of commerce, and in 1865 the imports had reached 3,000,000 lbs.; in 1870 they amounted to 3,888,536 lbs. It is said that European sheep are now displacing the alpaca and llama in the Peru-Bolivian Andes, the ass taking the place of the latter as a beast of burden.

The following table shows the imports of wool into Great Britain for the last sixty years, from which the reader will see the remarkable changes which have taken place in the sources of supply.

IMPORTS OF WOOL INTO GREAT BRITAIN FROM THE CHIEF WOOL-PRODUCING COUNTRIES.

Yr.	Spain.	Germany.	Australia.	South Africa.	East Indies.	South America.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1810	5,952,407	778,835	167	.....	.....	Trifling before 1833.
1820	3,536,229	5,113,442	99,415	29,719	.....	
1830	1,643,515	26,073,882	1,967,279	33,407	.....	
1840	1,266,905	21,812,099	9,721,243	751,741	2,441,370	4,378,274
1850	440,751	9,166,731	39,018,221	5,709,529	3,473,252	5,296,648
1855	68,000	6,128,000	49,142,000	11,075,000	14,283,000	7,106,000
1860	1,000,000	9,292,000	59,166,000	16,574,000	20,214,000	8,950,000
1865	115,000	6,858,000	109,734,000	29,220,000	17,105,000	17,867,000
1870	25,262	4,559,000	175,081,427	32,785,271	11,143,148	12,457,631

It is necessary to state that in the above table alpaca wool is included in the figures under "South America," and that the large imports from Russia and France already given, as well as smaller supplies from other countries, are omitted. The total imports for 1855, 1860, 1865, and 1870 are as under:—

	1855.	1860.	1865.	1870.
	lbs.	lbs.	lbs.	lbs.
Total imports	99,300,000	148,396,000	212,206,000	263,250,499
„ exported ...	29,453,000	30,761,000	82,445,000	99,643,789
Left for consumption	69,847,000	117,635,000	129,761,000	163,606,710

To this we require to add the amount produced yearly in Great Britain, for which 160,000,000 lbs. is probably a low estimate, thus raising the quantity annually consumed in our manufactures to nearly 325,000,000 lbs.

But there is something more to take into account. Woollen rags, under the name of "shoddy," are now used to a very large extent in the manufacture of the cheaper kinds of cloth. So also, although the supply is much more limited, is the wool of worn-out fabrics mixed with cotton. In this case the latter material is destroyed by a chemical process, leaving the wool intact, which is then called "extract." Technically speaking, soft woollen rags, as flannels, blankets, and stockings, are converted into "shoddy," and hard and fine woollen rags, including new cloth cuttings, into "mungo." But shoddy, as a general term, includes also mungo and extract. Although it is now about sixty years since the use of shoddy in the manufacture of woollen goods commenced, yet it is not more than half that period since it began to be largely employed. It is now, however, an indispensable material for medium and cheap clothing, second only in importance to wool itself. The amount of "shoddy" imported in 1870 was fully 21,000,000 lbs., and the annual home production was estimated in 1865 to be 52,000,000 lbs. Altogether, the amount of this formerly "waste material" now yearly consumed in our woollen manufactures cannot be less than between eighty and ninety million pounds.

In the *Journal of the Society of Arts* for June 14, 1872, the following table is given, which shows the estimated production of the countries which contributed wool to Europe and America during 1871:—England, 159,969,000 lbs.; Australia, 152,500,000; Van Diemen's Land, 6,136,000; New Zealand, 28,875,000; Cape of Good Hope, 38,000,000; La Plata, 138,070,000; East Indies, 18,797,000; Russia, 90,760,000; Sweden, 6,082,000; Norway, 6,395,000; Greece, 7,618,000; Denmark, 7,034,000; Holland, 6,130,000; Belgium, 3,500,000; Switzerland, 1,336,000; United States, 177,000,000; France, 91,608,000; Spain, 74,433,000; Germany, 52,080,000; Austria, 31,075,000; Italy, 24,840,000. Total, 1,121,519,000 lbs.

Of materials analogous to wool we have already mentioned the down, or "shawl wool" from the Thibetan goat. But so far at least as quantity is concerned, the woolly hair, called *mohair*, which forms the fleece of the Angora goat (*Capra Angorensis*) is of far more importance. This valuable goat inhabits the mountains in the neighbourhood of Angora, in Asia Minor. We formerly noticed the fact that fabrics had been made of mohair in Italy in the fourteenth century, but in modern times and among Western nations, it is only since 1848 that the value of this beautiful textile material has been appreciated. The staple of mohair is from five to six inches long, and hangs in curls. It is much esteemed for its silky appearance and its milky whiteness. At Bradford and Norwich, as also in France and other countries, it is largely made into fabrics for ladies' wear, linings, tabinets, plushes, and velvets; but in most cases it is mixed with other fibres. The hair of the common goat is also used for manufacturing purposes, although the quantity obtained is not large. In 1870 our total imports of goats' hair or wool amounted to 3,078,506 lbs., the larger proportion of which came from Turkey. Camels' hair, which strongly resembles wool, is woven into cloth in Egypt and Turkey, and in Russia strong military clothing is made of it. The hair obtained from the ox, and in small quantities from some fur-yielding animals, also finds several applications in the arts. To the furs used in making special kinds of felted goods we shall refer again.

GREAT MANUFACTURES OF LITTLE THINGS.—XIII.

CABINET BRASS-FOUNDRY.

BY CHARLES HIBBS.

The reader has but to glance round the apartment in which he happens to be, and notice the different brass articles that he sees attached to the woodwork of the building or the furniture, to know what is meant by cabinet brass-foundry. There are other branches of the industry entirely distinct and separate from this, which we shall not require to go into, such as the manufacture of gas-fittings and gaseliers, tube-drawing, cock-founding, etc. These are mostly carried on as independent trades by manufacturers who produce nothing else; or, where they form part of the production of a large general brass-founding establishment, have separate departments assigned them under separate management. The rolling of sheet brass may be also said to belong to the trade, but as that is generally performed in large metal rolling-mills, which also reduce ingots of copper, German silver, and plated metal to the sheet form, to suit the convenience of a multitude of businesses in which the staple raw material takes this shape, we have nothing to do with that either. In cabinet brass-foundry is comprised all the "little things" which are made of this beautiful and useful metal, such as brass knobs, sash-fasteners, blind-pulleys, bell-pulls, hat-pegs, curtain-rings, letter-clips, cupboard-fastenings and bolts, table and chair castors, stair rods, and an infinite number of miscellaneous and incongruous articles, from heathen idols to brass-headed nails.

Before proceeding to describe the methods by which these articles are produced, it will be proper to advert for a moment to the composition of the metal of which they are made. The brass of modern commerce is of comparatively late introduction; that which is known by the name in ancient sacred and profane records being probably bronze, a mixture of copper and tin. The brass vessels of the Temple, and the brazen pillars and the lavers, and the molten sea, which contained 2,000 baths, and the innumerable utensils which Hiram made for King Solomon, were of this metal. At least it is certain that none of the examples of ancient metallic art that have yet been discovered yield any evidence that zinc, the second ingredient in

the composition of brass, was knowingly made use of. It may have happened that calamine, or *cadmia* as it is called by Pliny, which is the ore of zinc, was found occasionally in such close proximity to the ore of copper as to lead to the accidental fusion of the two metals, such a mixture being probably that alluded to by ancient writers as yellow copper; but the alliance of copper with zinc, now one of the most common processes in metallurgy, seems not to have been thought of as an art until after the Christian era. The Romans had a metal called *orichalcum*, which appears to have closely resembled our brass, and was perhaps composed of the same ingredients, and it was of this that Vitellius caused copies to be made of the ornaments that enriched the temples of the gods, afterwards fraudulently substituting them for the real objects, which were of gold. Brass-working was practised by the Flemish and Germans long before its introduction to this country; and the monumental brasses which adorned our old cathedrals were imported from those countries.

Our forefathers long continued to make brass in a manner which, to our notions, seems strangely cumbrous and slow. Every caster now mixes the metal for himself, it being simply a compound of copper and spelter—*i.e.*, zinc—in proportions determined by the quality of the brass it is intended to produce. The copper is first put into the crucible, and the spelter, broken into small pieces, is dropped in when the copper is in a melted state. But it was formerly considered necessary to smelt together the ores of the two metals, and for this purpose immense furnaces had to be used, and the most elaborate operations carried on. The furnace was in shape somewhat like the dome of a glass-house, and within it were ranged nine great pots of fire-clay, the largest, or *king-pot*, being in the centre. These were charged with calcined calamine and coal mixed intimately together, having been ground fine with water and passed through a sieve, to which was added a certain quantity of bean copper. Plenty of fuel was then distributed about the furnace, and well packed in between the pots, and after the whole mass of ore had been subjected to intense heat for twelve hours, the furnace was re-opened, the contents of the pots well stirred, and the mixing rendered complete by pouring the metal from the smaller pots into the king-pot, which was again exposed to heat for a time, and afterwards skimmed for impurities. The great difficulty in this process seems to have been, that the calamine, or ore, would yield metallic zinc in indeterminate quantities, and great experience and caution were necessary to ensure the production of a fixed quality of brass.

The various articles of cabinet brass-foundry are produced in the first place either by casting or stamping. If by the first, they are spoken of as wrought, or solid work. The casting-shop in a well-ordered manufactory stands apart from the other buildings, lighted and well ventilated from the roof, with a tall chimney to carry off the fumes, which are very deleterious, especially if the caster is careless enough to let his pot of metal get over-heated, in which case the spelter flies off in minute flakes and noxious vapour. Too commonly a shop on the ground-floor of a two or three-storey range is made use of, and the suffocating fumes ascend through the floors to the shops above. The furnace need not be large, two pots being sufficient for a caster and his assistant to keep going at one time, their size being about that of a common flower-pot, only longer. These are lifted perpendicularly out of the furnace with a pair of tongs which clip them round, and afford a good leverage for pouring. Round the sides of the shops are wide troughs filled with sand, which, from being turned black by frequent use, looks more like garden mould than anything else. Good casting sand has its value; and when the ground is turned over for building operations in the neighbourhood of a town where metal industries are carried on, the discovery of a bed of sand is often productive of as much profit to the owner as the finding of a seam of coal. The brass caster makes use of moulds of an oblong square form, composed of two stout rims of iron, with front and back boards, and wooden screw-clamps to hold the whole firmly together. Filling one half of this box with sand, which he kneads down tightly with his hands and strikes off level with a straight-edge, he presses the patterns down upon it, placing them flatwise or sidewise according to their shape, and half buries them in the compact bed. He then shakes dry dust over the surface from a bag, and fitting the other half of the box on the top he fills that with sand also, pressing it well down, and stamping on it with his feet. The top board is then laid on, the mould turned deftly over, and the first half lifted off, when the sand will part cleanly in the middle, leaving the patterns behind in their second bed. They are now carefully picked out one by one, so that the mould when put together contains a perfect print of each of them. But before the two halves of the mould are joined, the caster has to make channels for the metal from the pouring holes in the iron rim to the prints, by scooping out little gutters in the sand, connecting two or more prints where necessary in the same manner. In the case of hollow castings, he has also to place the cores, a very delicate process, sometimes requiring great care and dexterity of hand. A little explanation is here necessary as to the construction of the patterns and cores. The patterns for small articles are perhaps first of all roughly shaped in wood, and a casting then taken in lead, which is trimmed down nearer to the final size and fashion. A second casting in brass enables the pattern-maker to produce a perfect model by filing, turning, or otherwise shaping it, as required. Should an ornamental raised design be intended to appear upon the article, it must be now modelled upon the pattern in wax, and a third casting taken, which must be cleanly finished and chased up. The pattern-maker, to say nothing of the taste he may be called upon to exhibit, should be a man of considerable mechanical knowledge and skill. He must know exactly how to adapt his article to the purposes for which it is wanted, and he must also know how far he may presume upon the resources of the caster's art. He must not make a pattern that it is impossible to cast, and especially he must take care that, however intricate it may be, its sides and angles must be so inclined as to leave the sand. If it is to be a hollow casting, the pattern must not be made hollow, but, on the contrary, must have projections upon it, in addition to being solid throughout. Thus, if the article to be cast be of hollow cylindrical shape, the pattern-maker will construct a core mould or box, the matrix in which will be a correct copy of the interior shape of the cylinder, with elongations at the two ends. This box dividing into two halves, enables the caster to obtain a reverse model of the interior in moistened and compressed sand. He will lay this in his mould after the pattern has been taken out, and the metal will run round it, filling up the space between that and the outer print. The pattern-maker has therefore to leave on his first model projections corresponding to the elongated ends of the core, so that they may leave a print in the caster's mould, and enable him to lay the core exactly in its proper place. Allowance must be made at each step of the process for the shrinkage of the metal while cooling, so that the final pattern may be just sufficiently larger than the article to be cast from it. Should there be deep indentations or under-cuttings in the pattern, which would tear away part of the mould on being lifted out, the caster has to resort to a process called false coring, which is the most difficult of all his operations. He first fills these interstices with moistened sand, which he well dries and smooths off, and thus produces an artificial surface, capable of leaving the mould easily. When he has procured a good print from the pattern so metamorphosed, he picks out the cores carefully from the pattern without breaking them, and builds them up in the mould in their proper places, the greatest nicety being requisite, until the matrix is complete. The whole of the moulding frames having been prepared for the entrance of the metal, and screwed up tightly, are ranged along the shop in an upright position, mouths uppermost, and the caster, tying a handkerchief over his mouth to guard against the fumes, lifts the pot from its fiery bed, and quickly goes down the row, pouring a little of the molten metal into each hole until it comes gurgling up to the top, emitting a whitish-blue flame with sulphurous vapour. A few minutes suffices for the operation, and the metal, which is of a dull coppery red when melted, sets immediately, so that no time need be lost in breaking up the moulds. Each in turn is lifted into the trough, unscrewed, and the contents, sand and castings together, tumbled out in a heap. Some will be found to be imperfect, the metal not having reached the extremities of the print, while some will be damaged from the sand having broken down, but the majority, in the hands of a good workman, will be clean sound castings, beautiful in their newness, and perfect copies of the patterns. When cooled sufficiently, they are picked out from the still smoking heap of mould, beaten to free them from adhering particles, and broken off from the

"gets," which are the thin strips of metal filling the connecting gutters. It may happen that these "gets" have absorbed as much weight of metal as the castings themselves, especially if there has been a run on small articles for that pouring, these being treated in a peculiar way by the pattern-maker. To mould each one separately would give the caster endless trouble, so the pattern-maker connects a number of them in a "spray," *i.e.*, a central stem, with branches springing out on either side, and at the end of each branch a pattern of the article. A quantity can thus be moulded at one operation, effecting a great saving of time, though there is the drawback of a great part of the metal being necessarily run to waste, the gets and sprays having all to be re-melted when their purpose has been served. The making of these sprays does not involve so much labour as might appear. The pattern-maker will in the first instance make but one pattern of the article, and the caster sticking this occasionally in an odd corner of his mould, will get from it a number of duplicates in due time. Being trimmed up, these will do duty as patterns, and the caster, moulding them in two rows, will connect them in spray fashion by scooping out channels in the sand. From the rough casting thus obtained a final and perfect spray pattern can be made. But little now remains to be described in the casting process. The cores, which are by this time baked hard, have to be picked out of the hollows, the sand brushed out of the bends and corners, and the castings are ready for the warehouse. An allowance of 5 or 6 lbs. per hundredweight is made for waste, as at each re-melting some part of the volatile zinc will fly off, especially when the metal has to be heated to a high degree to produce castings of a fine and intricate pattern. The extreme delicacy of detail obtained sometimes is really surprising. The writer has seen a sprig of double parsley reproduced in cast metal, all the feathery lightness of the original preserved, and the parts not disarranged in the slightest degree. Within the last two or three years a beautiful method of obtaining highly finished castings has been introduced from America. The mould is made of the finest sand, faced with wood charcoal reduced to an impalpable powder. It is forced by extreme pressure to take every line of the pattern, and the hot metal is also mechanically compressed into all the delicate markings of the mould. Castings from chased and engraved surfaces are thus produced which are scarcely to be distinguished from the originals.

The second method of giving initial form and shape to brass articles is by stamping. Rolled sheet, and not ingot brass, is the material now used, and the metal being laid upon a die, is forced to take its shape by repeated blows. It resembles, therefore, beaten or *repoussé* work, when finished, the contour of the relievo being followed in the depressions of the under side. Much saving of weight is thus effected, and brass becomes applicable to a variety of ornamental purposes in which lightness is a desideratum. The introduction of stamped brass-foundry created a new era in the trade. A writer of the time, speaking of it, said:—"The old process of casting is utterly laid aside, and a more cheap and expeditious method is substituted. Artists of inventive minds and unwearied application have called in the use of dies, presses, and stamps; and one man can, in the same space of time, produce what, on the old principle, would have required ten to perform, and by this improvement beauty and elegance may be obtained without incurring the enormous expense which has hitherto accompanied them." Although it is quite true that by this means forms of lightness and beauty can be produced at less expense, it will be long before the "old process of casting" is superseded by the stamp and die. The early stampers were timid, and used only shallow dies, not knowing the extent to which the ductility of the metal would allow them to punch and torture it into shape, but now there is scarcely any degree of relief that cannot be obtained. The die itself we need not describe; the mechanical reader will know that it is a block of steel welded in a larger block of iron, the impression of the intended work cut in its face. This block the stamper lays upon the stamp-bed, immediately under the descending hammer, and fixes it there by tightening up four strong screws, which surround it horizontally. He has now to consider how many rests the metal will require before it can be forced into all the depressions of the die. If the pattern be sharp and deep, it will require a good many, being re-annealed each time. The stamper perhaps first begins by half filling his die with clay, plastering up all the sharp indentations; he will then take a cast of the hole with melted lead, having first surrounded it with rolls of clay to prevent the metal from running over. When cold, he lets the stamp-hammer down sharply, which being furnished with roughened studs upon its under side, lays hold of the lead "force" and picks it up when re-lifted. This shapeless lump, which resembles the face of a statue when the features have been all worn away and obliterated by age, is now made to descend upon the thin metal, and gives it the first rudiment of the form it is ultimately to assume. Successive operations of the same kind bring it up gradually nearer and nearer to a finish, and the final strokes are given by a "force" cast in brass or some harder alloy in the clean die. Repeated annealings prevent the metal cracking or "flying" in the process, and the acme of art consists in producing a stamping unbroken in any part, and yet reaching the utmost limit of tenuity that the metal can be made to bear.

Formerly, stamping was a most laborious process, the ram or head of the stamp being necessarily heavy, sometimes a hundredweight or more. Where steam-power is used upon the premises, however, a great assistance can be given to the workmen by the simple expedient of passing the rope over a pulley which is connected with the shafting of the machinery. This pulley being constantly revolving at moderate speed, it is sufficient merely to tighten the rope upon it, and it will pull up the weight without much manual effort being exercised. The aid of two "pullers" used to be required for the heavier kinds of work, but now a man of moderate strength can work the most powerful stamp unaided.

A glance at the pattern-books of a large manufactory would show how enormous must be the number of dies which pass through the hands of the managers in the course of a year. The variety seems to be inexhaustible. Not only does every day bring up a call for something never made before, but every staple article has been subjected to innumerable mutations from the changes of fashion, while some have gone out of sale altogether. The dies for the stamper, and the patterns for the caster—both of which are in many cases most expensively got up—form no small part of the fixed capital of the manufacturer. The effect is to operate detrimentally to the progress of pure taste, on account of which a great deal of undeserved obloquy has been cast upon the trade. Some of the leading manufacturers are men of cultivated minds, who are as desirous of improving the style of their work as any art-critic could possibly wish them to be; but in order to keep a balance on the right side of the ledger, they are compelled often to pander to the depraved appetites of purchasers, and are always timid at departing from the beaten track. Novelty is of course sought after, but it must be novelty within the limits of certain styles which the public may be trusted to buy, and vicious ornamentation is unfortunately more the rule than the exception. A die that costs several pounds will be worth only a few pence when its design has ceased to be popular, and in addition there is the contingency of having a large quantity of finished articles lying as dead stock in the market. When it is considered how many hands these pass through in the course of distribution, and that each person concerned has a deep interest in keeping on the safe side, and not trying hazardous experiments on the public taste, it will be seen how narrow is the field for the display of real artistic fancy. A revolution is in progress, nevertheless, but it must come from the outside: it must depend upon the gradual improvement of those who buy and use the products, and it must necessarily be slow.

We have now brought our notice of brass-working up to the point at which the roughly-shaped articles pass into the finishing shops, where they are subjected to the interesting processes which render them presentable for the market. At that point we must leave them for the present.

THE LATHE.—XIII.

By Henry Northcott.

SELF-ACTING LATHES.

The slide-rest or sliding tool-holder would not be of much use for such work as described in the last article, as for most of the work hand-tools would be both more convenient and much more expeditious. The ruler, however, may be to some extent an

exception, as for finishing this the slide-rest would have an advantage over the hand-tool, inasmuch as it would, if properly adjusted and manipulated, leave the ruler parallel, whereas to finish a ruler by hand-tools requires a good deal of care and trouble. If a slide-rest be used, a very slight scraping only should be left for the finishing cut, and this should be taken with a carefully sharpened tool. For this work the lathe requires to rotate at a high speed, and the slide-rest is actuated by hand. The winch-handle may be continuously worked without producing too coarse a traverse. Some modes of rendering the slide-rest self-acting have been already described in connection with simple hand-turning lathes, to which these motions are usually applied; but it is not surprising that when a great deal of parallel work was required, the mechanic should have looked about to see if some simpler and more convenient mode of actuating a sliding tool could not be devised. One very apparent means was that of substituting two spur-wheels for the carrier and stud-wheel shown at Fig. 23 (Vol. III., p. 257). This would give a continuous movement to the tool; but unless the pitch of the traverse-screw of the rest were made very fine it would be necessary to use a very small pinion for the work, and a very large wheel for the screw, in order that the cut of the tool might not be too coarse. Again, as the teeth of the wheels could not be made very long, this connection was rather an inconvenient one, excepting to those slide-rests which allowed the tool to be moved towards or from the work without moving the traverse-slide. Some slide-rests were arranged so as to be driven by a cord or band from an overhead shaft, and passing over two small stepped pulleys. This plan was somewhat more convenient, as it did not interfere much with the movement of the rest; and the stepped pulley could be placed upon either of the slide-rest screws, so as to produce a cylinder or a surface. The pulleys being stepped, also enabled the speed of the traverse or thickness of the cut to be varied for different materials, or when required. But the greatest improvement was effected by converting the lathe-bed itself into a slide, and arranging mechanism to the lathe for moving the slide-rest bodily along the slide thus formed. Lathes of this class are termed "self-acting lathes," or "screw-cutting lathes," according to the nature of the mechanism employed to move the slide-rest along. If a screw and set of wheels be employed, the lathe is usually termed a screw-cutting lathe; but if a rack and pinion, or any other means be used, then the lathe would be known as a self-acting lathe. Many lathes are fitted with a rack and pinion, or other mechanism, to render the movement automatic, and also with a screw and change-wheels for screw-cutting. These lathes are termed self-acting and screw-cutting lathes; and the reason that two sets of mechanism are employed to produce apparently the same kind of motion is that the screw may be reserved for screw-cutting only, as its continual use for ordinary turning soon wears it unequally, and unfits it for accurate screw-cutting.

Fig. 100 shows a very good self-acting lathe made by Messrs. Fairbairn, Kennedy, and Naylor, of Leeds. This lathe is a good specimen of the class of self-acting lathes in use in large engineering establishments for general work. It is self-acting on both the longitudinal and transverse cuts, so that the mechanism enables both cylinders and surfaces to be produced without any handle-turning on the part of the workman. The lathe has back gearing for the purpose of getting slow speeds and great power, and the general arrangement of the lathe is much the same as of some of those described already; but the proportions are more massive and substantial. The upper part of the bed is flat, as before, but it is carried a little further outwards, and its two edges are formed into a V-shape. The bottom of the slide-rest also is fitted with corresponding V's to embrace and slide along the lathe-bed. This arrangement, as will be seen, converts the whole length of the lathe-bed past the headstock into a slide for the entire slide-rest to travel upon. The lathe-spindle is continued outwards behind, and fitted to receive a three-speeded cone-pulley, and another similar cone-pulley is seen below, with a belt passing over both of them, so that when the lathe-spindle is in motion the lower cone-pulley is also caused to rotate. At the back of the lathe-bed, and out of sight in the illustration, is a long, slender shaft, one end of which is connected with the lower pulley, and driven from it by the spur-wheels seen between the two. These wheels may be thrown into or out of gear at will by means of the small handle at the side, so that the back shaft may be driven or not, as is required. The back shaft carries a sliding worm or tangent-screw, which gears into a suitable worm-wheel, a portion of which only comes into view; and the spindle carrying the worm-wheel is continued across the lathe-bed, through the metal of the slide-rest, and at its front end is furnished with a pinion, connected with the rack by spur-wheels, as shown. The large handle shown in front of the slide-rest is used for moving the rest along the bed to any required position; and such a provision is needed, as the self-acting motion is necessarily very slow.

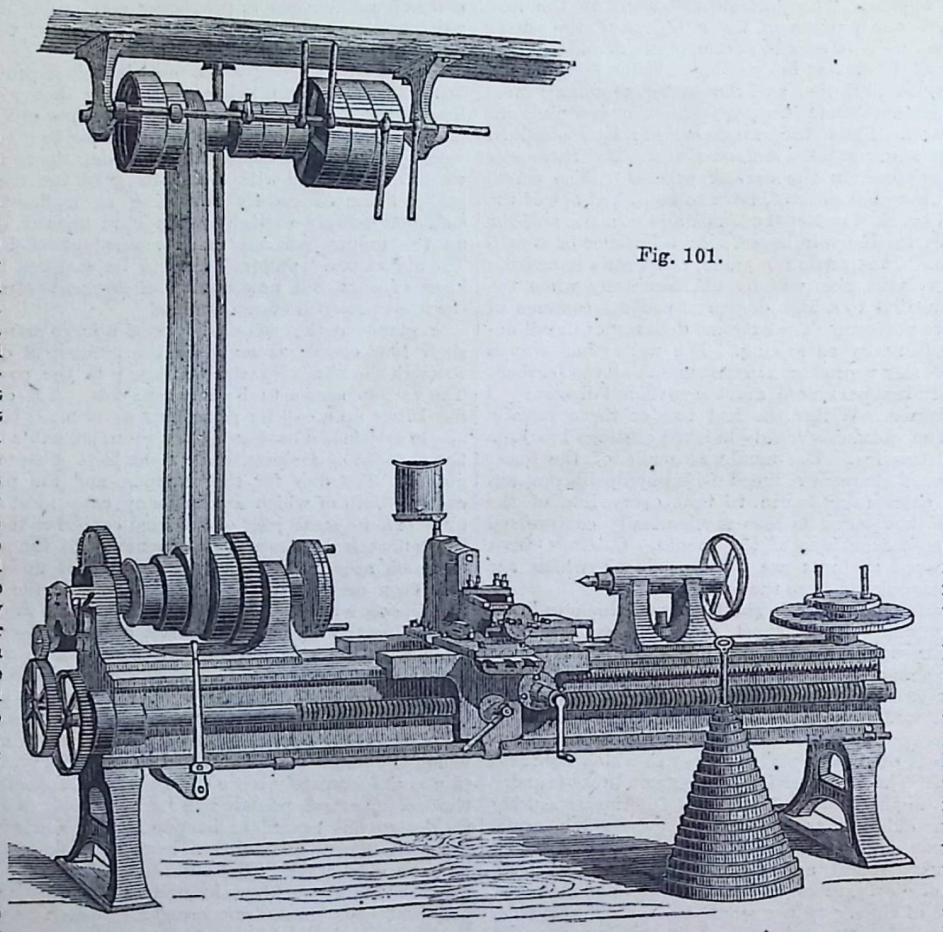


Fig. 101.

The lower part of the slide-rest is termed the saddle, and the

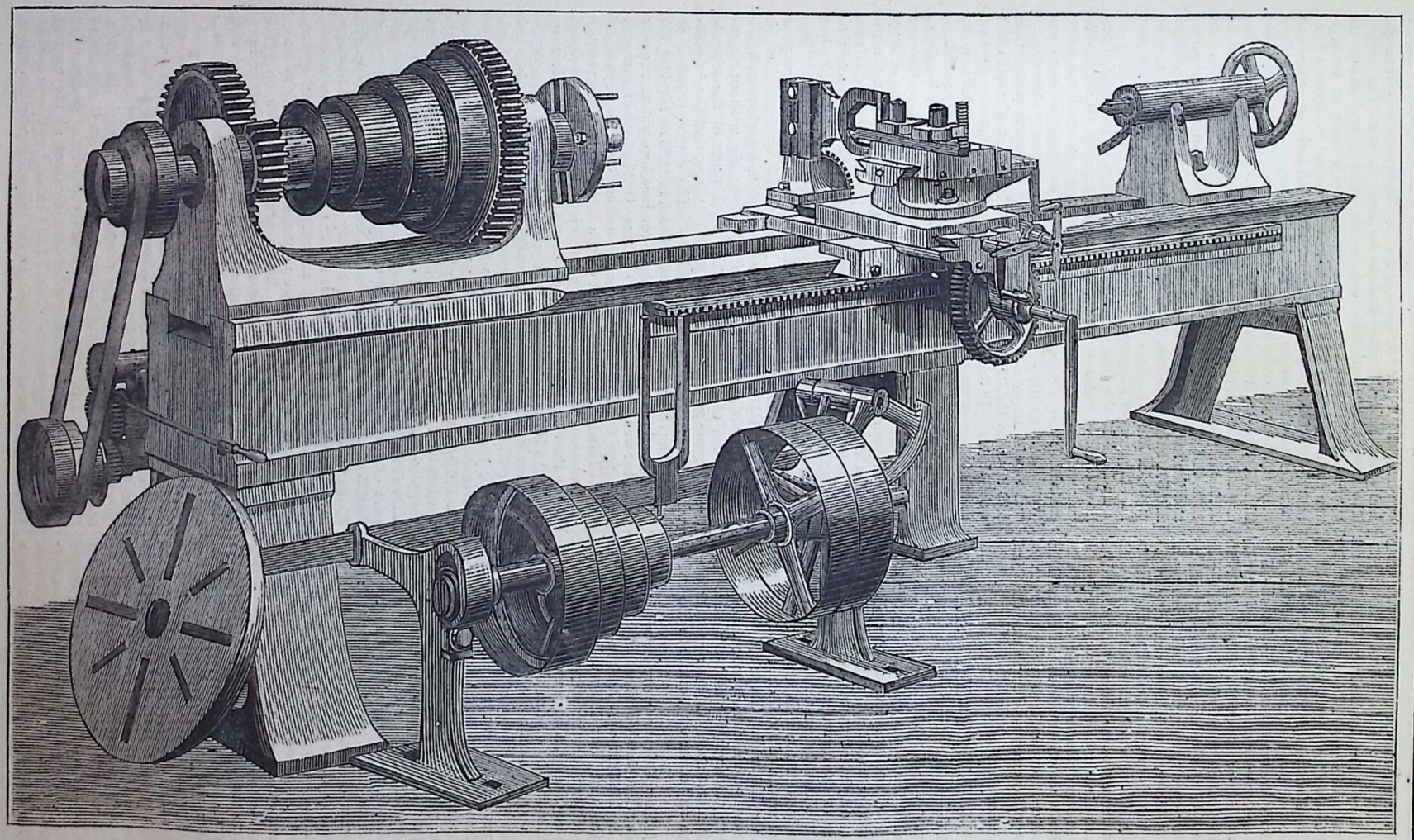


Fig. 100.—SELF-ACTING TURNING-LATHE MADE BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

saddle sliding along the bed of the lathe produces a parallel shaft or cylinder, when the headstocks are properly adjusted. The surfacing-slide is placed exactly at right angles to the lathe-bed slide, so that if the latter by its movement produces a cylinder, the former must necessarily produce a plane surface. Cylindrical shafts and surfaces are almost the only forms the lathe is called upon to turn out; but by altering the position of the line of lathe-centres relatively with the lathe-bed, the traverse-slide may be made to produce tapering shafts, and the surfacing-slide to produce angular instead of plane surfaces. Any small angular parts of the work are turned by the movement of the third or upper slide shown upon the surfacing-slide, and which may be placed at any angle to the work by simply moving a couple of screws; but this third slide must be actuated by hand.

The apparatus at the back of the slide-rest is used as a support for long and slender work, which, without something to hold it in its place, is constantly liable to spring from the tool instead of withstanding its cut. The actual bearing for the work consists of a hard-wood bearing

placed in the jaws of the stay, and it usually follows close behind the tool.

Fig. 101 is a screw-cutting lathe, by Muir, of Manchester. In this example the traverse of the slide-rest is obtained by means of a screw, termed the leading screw, and which is placed along the front of the bed. The screw is driven by means of a series of change-wheels from the end of the lathe-spindle, and the slide-rest is connected to the screw by means of a movable nut, which may be made to clasp the screw and engage with its threads by moving the left-hand handle of the slide-rest. With the lathe in motion, and the change-wheels in place and in gear with the pinion on the end of the spindle, the screw will be rotated at a speed depending upon the size and arrangements of the change-wheels. The slide-rest will, however, only move along the lathe-bed when the clasp-nut attached to the rest is closed upon the screw. The slide-rest of this lathe is made with the two upper slides apart from the saddle, so that the slides may be removed from it, and thus leave the upper surface of the saddle free to receive an engine cylinder or other article to be bored. The illustration shows also the mode in which the lathe is driven from the overhead counter-shaft; but the presence of two sets of idle and driving pulleys may need further explanation.

SEATS OF INDUSTRY.—XXXVI.

NEW ORLEANS.

BY WILLIAM WATT WEBSTER.

New Orleans, the capital of the State of Louisiana, and the commercial metropolis of the southern and western portion of the American Union, extends for about six miles along the left bank of the Mississippi, on a bend of the river shaped like the letter S. The older quarter of the town lying along the outer curve, gave it the name of "The Crescent City." It is situated at a point about 105 miles from the mouth of the Mississippi, about 1,000 miles below the mouth of the Ohio, and about 1,200 miles below the mouth of the Missouri. These rivers and their tributaries give New Orleans steamboat communication with 20,000 miles of river, passing through the richest soils and the pleasantest climates; and it consequently enjoys a greater extent of internal navigation than any other city, either in the Old or in the New World.

The first settlement at New Orleans was formed in 1718, under the direction of Bienville, the Governor of the French province of Louisiana. In 1722 it was spoken of as "the famous town named New Orleans;" but Charlevoix, who visited the place in that year, describes it as consisting of "a hundred cabins, disposed with little regularity, a large wooden warehouse, two or three dwellings that would be no ornaments to a French village, and the half of a sorry storehouse, which they were pleased to lend to the Lord, but of which He had scarcely taken possession when it was proposed to turn Him out to lodge under a tent." Shortly after this date, however, large numbers of French Jesuits and Ursuline nuns took up their abode in the town, and there was then plenty of provision for the teaching of religion; but little was done to develop the commercial resources of the district. In 1763, New Orleans, along with Louisiana, had to be transferred to Spain, about the same time that Canada was taken from the French by England; and it remained in the possession of Spain for upwards of thirty years, when it was restored to the French. In the year 1785 the town contained 4,980 inhabitants; and in 1788 a great fire broke out which destroyed 900 houses, and a vast deal of other property. In 1803, soon after the French had come again into possession of New Orleans, the vast territory of the Mississippi and the Missouri was sold to the United States by Napoleon I. At this date the town contained about 8,000 inhabitants, mostly French and Spanish; and by 1810 the population had more than doubled. The progress of New Orleans after its cession to the United States was exceedingly rapid. Colonisation was then making very rapid progress in the Central and Western States, and for nearly fifty years it seemed as if New Orleans were destined to outstrip New York in the extent of its commerce. It soon became the principal depôt for the cotton and tobacco of the Southern States; and its merchants made great efforts to retain their hold of this trade, by improving the means of river navigation. In 1810 only flat boats, pushed along with poles stuck into the mud, and occupying a hundred and twenty tedious days in the voyage between St. Louis and New Orleans, were to be seen on the Mississippi. The first steamboat that ever plied that river made its appearance in 1815, and accomplished the journey in twenty-five days. By 1860 this distance was traversed in seventy-four hours, by those flying river steamers, which have since become so notorious in America, through the frequency with which they blow up. The population of New Orleans in 1820 numbered 27,176, and by 1830 it had risen to 46,310. In 1817 the exports of cotton amounted to 65,000 bales, and of tobacco to 28,000 hogsheads, besides other produce of various kinds. In 1830, 354,024 bales of cotton were exported from New Orleans; and the imports from the interior in the preceding year included 269,571 bales of cotton, 157,323 barrels of flour, 146,203 pigs of pig-iron, 110,206 kegs of lard, 28,432 hogsheads of tobacco, and 13,472 pieces of bagging.

In 1814-15 the British landed a large force in the neighbourhood of New Orleans, which made an unsuccessful attack on the entrenchments of General Jackson, and had to re-embark, after sustaining very severe losses. Up to the outbreak of the Civil War the prosperity of the city continued to increase with steady and almost unprecedented rapidity. By 1850 the population had risen to 126,375, and by 1860 to 168,823, of whom 13,380 were slaves. In 1848 the exports of cotton from the port of New Orleans amounted to 1,201,897 bales, and of tobacco to 60,364 hogsheads; while a proportionate increase had taken place in the exportation of other important articles of produce, and especially in breadstuffs. Owing to the rapid settlement of the Western States, the progress made in the trade of New Orleans during the succeeding ten years was still more astonishing. The total value of the American produce exported from New Orleans in the year ending June 30, 1858, amounted to 88,270,224 dollars, against 89,039,741 dollars for New York; but the imports into New Orleans only reached a total of 19,586,033 dollars, against 178,475,736 for New York. In 1860, the year before hostilities were actually commenced by the Federals, there cleared the port of New Orleans 958 American and 335 foreign vessels, making a total of 1,293 vessels, with an aggregate burden of 894,353 tons. The total value of the exports for that year amounted to 108,293,567 dollars, and the imports were returned at 22,920,849 dollars. The cotton received at New Orleans from the interior was valued in 1860 at 109,000,000 dollars, and the value of the whole produce brought to the city that year was about 185,000,000 dollars. On the 25th of January, 1861, New Orleans joined in the insurrectionary movement of the "Confederate States," and on the same day the Convention of Louisiana passed an "Ordinance of Secession." For about a year the city remained in the possession of the Confederates. From the 10th of June, 1861, to the 1st of June, 1862, the legitimate trade of the port was suspended by a blockade. Admiral Farragut, in command of a portion of the United States fleet, having previously destroyed the fleet of the insurgents in the Lower Mississippi, and having run past Forts Jackson and St. Philip, suddenly appeared before New Orleans, which surrendered on the 28th of April, 1862, after negotiations that occupied two days. The loss of this city was the first great blow that the Confederates received. In 1861 there cleared the port of New Orleans only 130 vessels, with a total burden of 75,935 tons. Writing before the outbreak of the Civil War, Mr. Flint, in his "Geography and History of the Western States," says: "There have been counted in the harbour of New Orleans 1,500 flat boats at a time. Steamboats are arriving and departing every hour; and it is not uncommon to see fifty of them lying in harbour together. There are often 5,000 or 6,000 boatmen from the upper country here at a time; and we have known thirty vessels advertised together for Liverpool and Havre. The intercourse with Havannah and Vera Cruz is great, and constantly increasing."

Although the blockade of New Orleans was raised in June, 1862, the lower valley of the Mississippi river and its tributaries, the State of Texas and other Southern States which supplied a large portion of its staple exports, and received a large quantity of its imports, were closed to commerce till 1865, and it was accordingly only after that date that the trade of the city began to resume its normal condition. In the year 1864-65, the total quantity of cotton received at the port of New Orleans only amounted to 271,015 bales, but it was sold at an average price of 69¼ cents. In the following year the cotton

receipts rose to 787,386 bales, which brought an average price of 39¼ cents. By 1868-69, the quantity had risen to 841,216, sold at an average price of 25¾ cents; by 1869-70, to 1,207,333 bales, at an average of 22 cents; and by 1870-71, to 1,548,136 bales, at an average of 14¾ cents. The total receipts of cotton at New Orleans and other delivery ports in 1869-70 exhibited an increase of 43 per cent. on the previous year, and of 80 per cent. on the year 1867-68; and the total receipts for 1870-71 showed an increase of 25 per cent. over those of the preceding year, but owing to the fall in price the larger crop of 1870-71 did not realise within 30,000,000 dollars of the sum obtained for the smaller crop of 1869-70. The receipts of sugar and molasses show a still greater increase, which is largely attributable to wider cultivation, the use of healthier cane-seed, and generally favourable weather. Receipts of tobacco and other produce also show an increase; but in some articles, including wheat, there was a decline in 1870-71, as compared with the preceding year. Summing up the statistics of the trade of New Orleans, in his report to Parliament for 1871, the English Consul says:—"The general result is a marked progress in Southern staples, with the exception of rice, and little or no improvement, if not an actual retrogression, in Western produce; and a glance at the railway map of the United States will show the reason why a large and increasing portion of produce which used to be sent down the Mississippi to be exported from New Orleans, is now sent up, to be forwarded by rail to Philadelphia, Baltimore, and even to New York, and, as a matter of course, imports find their way by the same routes." In another part of his report, Consul de Fonblanque says, in reference to the past history and immediate prospects of the commerce of New Orleans: "The old theory that land carriage cannot compete with water carriage is nowhere more thoroughly exploded than in the United States; and it is, perhaps, over-reliance upon its great river as the sole means of transport that has lost New Orleans a part of her trade. Delay, exposure to the weather, and too much handling of goods, are the evils set down against water carriage. If, as seems probable, a line of railway opening up the State of Texas, and connecting this State (Louisiana) with the Pacific seaboard, be constructed, a great future is in store for the 'Crescent City.'"

But notwithstanding the great increase that has taken place in the trade of New Orleans since the close of the Civil War, there remains a considerable leeway to make up before the old amount of business will be reached. A portion of it has, it is to be feared, been finally diverted into new channels, and can never be resumed. New industries promise in some measure to compensate for this loss, and conspicuous among these is the utilisation of cotton-seed, which has recently been carried on in Louisiana to a large extent, 140,000 bags of cake made from cotton-seed having been exported from New Orleans in 1871, while during the first two months of 1872 no less than 66,000 bags were shipped. The shipping cleared at New Orleans for foreign ports in 1871 consisted of 364 American vessels, aggregating 277,765 tons burden, and with a total crew of 6,147; and 542 foreign vessels, aggregating 336,457 tons, and with a total crew of 9,095. In the same year 1,309 vessels engaged in the coasting trade, aggregating 1,108,668 tons, and with a total crew of 30,118, cleared the port. The British vessels that entered the port of New Orleans in 1871 numbered 271, with a total crew of 4,907. Regarding the enterprise of the merchants of New Orleans, and their mode of transacting their business, a very favourable impression is produced by the following paragraph in Consul de Fonblanque's report, showing the revolution in the manner of conducting operations in cotton, caused by the extension and improvement of telegraphy: "Every merchant of any pretensions has an instrument at his elbow as he sits in his office, by which prices are recorded. At what is nine o'clock a.m. in New Orleans, he knows the quotations made at Liverpool at eleven a.m. He has two other despatches per diem, and he hears from New York every hour." Valuable deposits of salt and sulphur are reported to have been discovered recently within a few miles of New Orleans, which only require the application of capital to yield handsome returns. At the present time New Orleans is the third shipping port in the United States, being inferior only to New York and Boston. It has railway communication to the north, the east, and the west, and a canal system connects it with Lake Pontchartrain. Vessels of the largest burden can navigate the Mississippi for hundreds of miles above New Orleans.

One great drawback to the prosperity of New Orleans is the unhealthiness of its site. It is built on a swamp from two to five feet below the level of the river at high water, and is surrounded by swamps that are even below the level of the river at lower stages. In order to keep out the waters of the Mississippi, a levee or platform, from 5 to 30 feet in height, and extending for about 100 miles along the bank of the river, has been constructed, partly out of deposit swept from the north by the Mississippi. Breaches are occasionally made in this dyke, but they are soon closed. It has been proposed to bring earth from the upper parts of the Mississippi, in order to raise the site above the level of the river at high water, but this great undertaking has always been deferred. As might be expected, yellow fever periodically visits the city, usually between the months of June and September, and this plague has sometimes carried off more than 8,000 of the inhabitants. A great number of the poor fall victims to yellow fever on every visitation, and the rich betake themselves to more healthy spots; but owing to improvements in the drainage of the contiguous swamps, and the substitution of stone for wooden sewers in the city itself, the virulence of this disease has been greatly mitigated within recent years. Owing to the damp nature of the ground, however, the houses in New Orleans have no cellars, and there are no graves in the cemeteries, the coffins with the dead being deposited in tombs or "ovens" erected above the soil. The appearance of the city from a distance is not striking, as there are few steeples to relieve the monotonous flat, and it has few public buildings remarkable either from their beauty or their associations. The cathedral, which has four towers and massive walls, ornamented with statues of saints in niches, is the only public edifice of an imposing character. In proportion to the population there are few churches in New Orleans, and it is not very well provided with schools, reading-rooms, or even with newspapers. It has, however, an unparalleled number of lottery-offices, billiard-rooms, and gambling-houses; and morals are reported to be at a lower ebb in New Orleans than in any other city in the United States. The theatres and hotels are on a gigantic scale. In no city in the world is a greater admixture of races to be seen, or a wider variety of languages, manners, and complexions. About one-half of the fixed population consists of black or coloured persons, including creoles of every shade. The bulk of the white population is of French and Spanish descent, but natives of every State in the Union and of every country in Europe are to be found in the motley community of New Orleans. In the older quarters of the city the houses are lofty structures, built chiefly of brick, and many of them are stuccoed on the outside, and painted white or yellow, besides being ornamented with tasteful cornices and iron balconies. These houses in many respects resemble those to be seen in old French and Spanish towns. Few of the streets in the old part of the city are 40 feet wide, and they are very irregularly laid out. In the new quarters the streets are wider and more regular, and the houses are built in the modern American style. During the hot season the street-doors of many of the houses of New Orleans are left open all day, and mosquito curtains are substituted for doors.

TECHNICAL DRAWING.—XC.

DRAWING FOR METAL-PLATE WORKERS (*continued*).

The careful student, really desirous of self-improvement, and anxious to gather that store of necessary technical information which can alone ensure his becoming superior to others in the daily practice of his calling, will now be perfectly competent to follow us in this and future lessons that we shall bring under his notice as being specially applicable to metal-plate workers. He has also gained another invaluable piece of knowledge, that bears on the ultimate attainment of success in every position of life, be it what it may, that an intimate acquaintance with the first principles of any branch of learning is the great corner-stone of well-doing and well-being for the future, and that this basis must be carefully built upon by practice and application.

To draw an ellipse which shall be the true section of a cone on a given line.

This lesson is repeated from "Projection," so that by substituting another drawing certain parts may be more especially brought out.

If a cone be cut across so that the plane of section may pass through the axis at an angle and cut the slanting surface of the cone on the opposite sides, the section is called an *ellipse*.

An *ellipse* differs from an *oval* in being the same at both ends; whilst in an oval the one end is more pointed than the other. See "Practical Geometry applied to Linear Drawing," in which are given various methods for describing the conic sections as plane figures; whilst in "Projection" will be found the methods of obtaining the parabola and hyperbola by means of projection from given sections in cones.

Let Fig. 658 be the plan and elevation of the cone, and A B the line of section.

Divide the circumference of the plan into any number of equal parts, C, D, E, F, G, H, I, and D′, E′, F′, G′, H′, I, and draw radii.

Project these points on to the base of the elevation of the cone, and from C″, D″, etc., draw lines to the apex J′.

The diagram up to this point represents a cone on the slanting surface of which straight lines have been drawn, which, on looking down on the apex, would appear as radii of the circle forming the plan.

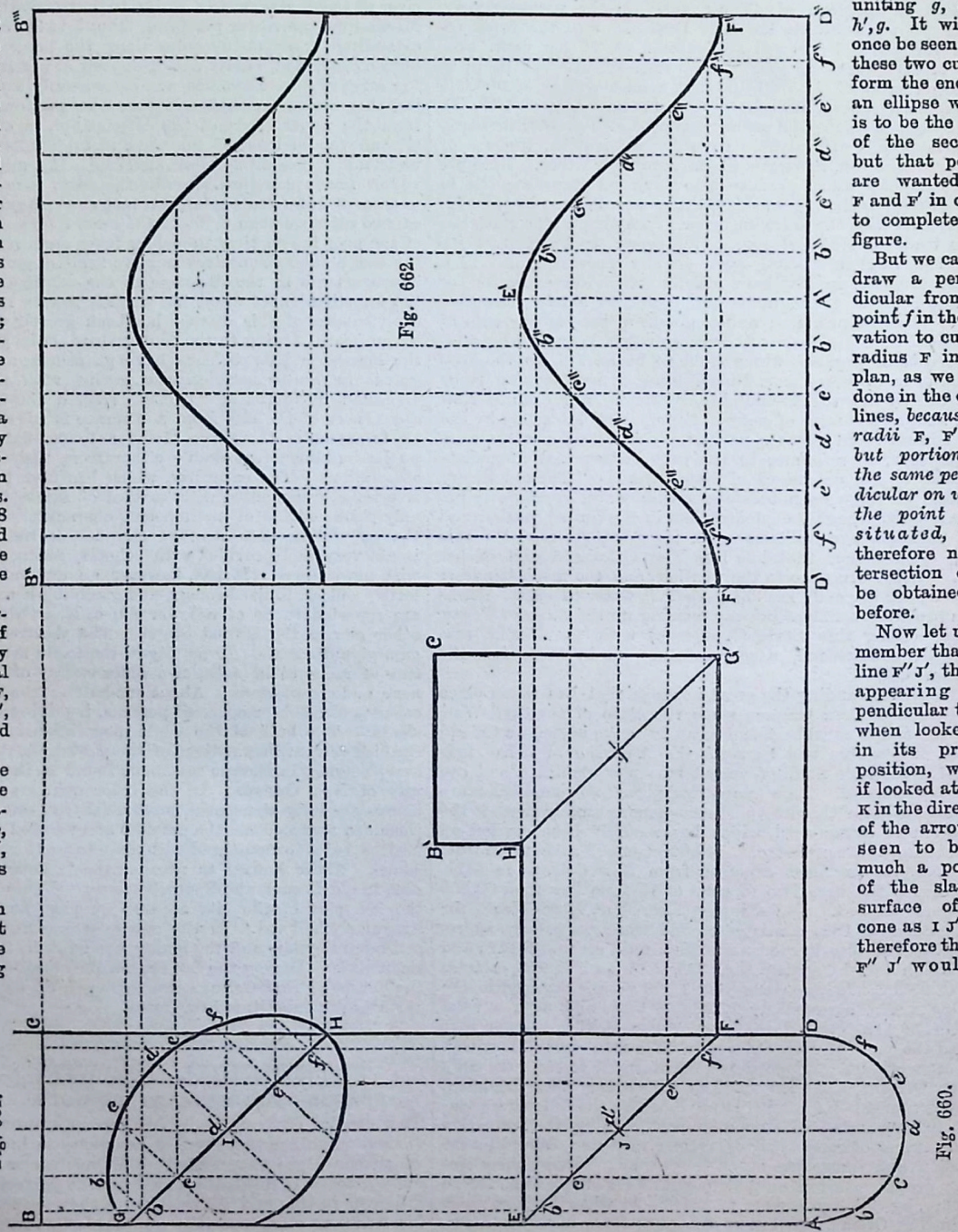
The line E″ J′ in the elevation is therefore represented by E J in the plan, and thus the plan of any point marked on E″ J′ must fall somewhere on the radius E J.

Now the section line, A B, cuts through all the lines drawn to the apex of the cone in the points *d*, *e*, *f*, *g*, *h*; and it will be remembered that although in the elevation the section is represented by a single line A B, it will assume a different form in the plan. From points A and B draw perpendiculars cutting the diameter C I in *a* and *b*, and from *d*, *e*, *g*, *h* in the elevation draw perpendiculars cutting the radii of the plan which are similarly lettered.

Draw the curve which will unite *e*, *d*, *a*, *d*, *e*, and also the curve uniting *g*, *h*, *b*, *h′*, *g*. It will at once be seen that these two curves form the ends of an ellipse which is to be the plan of the section, but that points are wanted on F and F′ in order to complete the figure.

But we cannot draw a perpendicular from the point *f* in the elevation to cut the radius F in the plan, as we have done in the other lines, *because the radii* F, F′ *are but portions of the same perpendicular on which the point f is situated*, and therefore no intersection could be obtained as before.

Now let us remember that the line F″ J′, though appearing perpendicular to I L when looked at in its present position, would, if looked at from K in the direction of the arrow, be seen to be as much a portion of the slanting surface of the cone as I J′, and therefore the line F″ J′ would be seen to make the same angle with the horizontal plane as I J′. If, then, we rotate the cone on its axis, the point *f* will move to *f f*, and a perpendicular drawn from *f f* will give us *f f* in the plan. If, now, we turn back the cone to its original position (which will be represented by drawing a quadrant from the centre of the plan with radius J *f f*), the quadrant will cut the radius F in *f′* and F′ in *f″*. Join *e* and *g*, and *e′* and *g′* by curves passing through *f* and *f′*, which will complete the plan of the section.



This is not, however, the *true section*, but the view when looking down upon it; and as it is slanting, its length from *a* to *b* will seem shorter than it really is.

It will be evident that the true length of the section is the line A B. From these points, then, and also from *d*, *e*, *f*, *g*, *h*, draw lines at right angles to the section line, and A′ B′ parallel to it. On each side of the points *d*, *e*, *f*, *g*, *h*, in the line A B, set off the distances which the points similarly lettered are from C I in the plan, and these will give the points through which the true section may be drawn.

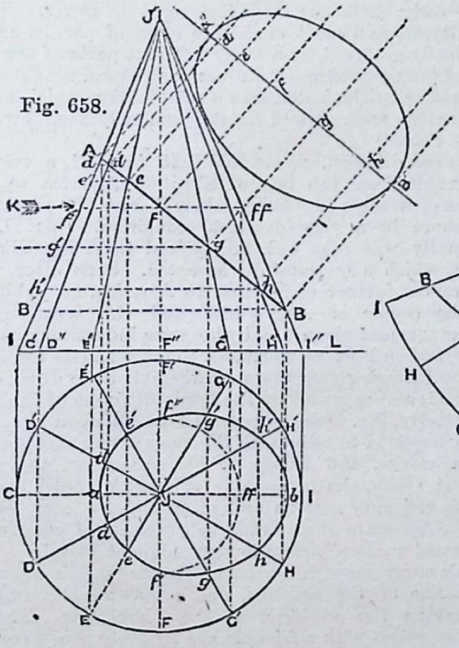
To metal-plate workers it will be a matter of importance to know the exact curve at which the metal must be cut, so that when formed into a cone it may be truncated—that is, cut off at the required angle.

We will, therefore, in the first place, develop the entire cone, and then mark on it the section line.

Fig. 659.—From any point, as J″, draw a line equal to J′ C′ in the elevation—viz., J″ C″—and with J″ C″ as radius describe an arc. On each side of C″ set off on this arc the equal distances C D, D E, etc., of the plan (Fig. 658).

Join I, I′ to J″, and the sector thus formed will be the development of the cone on which it is now required to trace the line of section.

Fig. 658.



To do this, draw lines to J″ from the points D, D′; E, E′; F F′, etc., already marked on the arc I I′.

From the points *d*, *e*, *f*, *g*, *h*, and B, in the section line A B, draw lines parallel to the base of the cone, cutting the line C′ J′ in *d*′, *e*′, *f*′, *g*′, *h*′, B′.

Now from C″ (Fig. 659) set off the length C′ A taken from Fig. 658—viz., C″ A′.

On the lines D′, D (Fig. 659), set off the length C′ *d* taken from Fig. 658—viz., D *d*, D′ *d*′.

Proceed thus for the other points, transferring the lengths on C′ J″ (Fig. 658) to the lines similarly lettered in Fig. 659, and through the points thus obtained draw the curve, the line in which the material would be cut, so that when I B and I B are brought together a truncated cone may be formed, the section of which on the line A B will be the ellipse A′ B′.

The student has already been reminded that if a solid be cut across, the parts will, when rotated on a centre, form an elbow—that is, they may be joined so as to turn a corner; or the parts may be turned obliquely to each other, forming an elbow of any required angle.

This principle holds equally good in relation to cylinders, and the following lesson is therefore (in order to save trouble of reference) repeated with additions and an enlarged drawing from "Projection."

Fig. 660 is the half plan, and Fig. 661, A B C D, is the elevation of a cylinder which it is required to cut so that when the parts are joined a double right-angled elbow pipe may be formed. The zinc-worker will at once see the usefulness of this study.

It is necessary that the student should again be reminded that whatever may be the required angle, the *section must be made at half that angle with the axis.*

Thus, if a pipe is to follow two walls which meet at an angle of 120°, each part must be cut at 60°. Therefore, in the present instance, draw the section lines E F and G H at 45° to the axis.

If now, supposing for the time the cylinder to be solid, the middle part be rotated on the pins I and J placed in the centres of the sections, and at right angles to E F and G H, the double elbow will be formed. The point E of the middle portion will move to F, and the point G will move to G′.

The point F of the middle portion will move to E of the lower, and H will move to H′.

In this operation it will be seen that the lower part is not moved at all, and that the upper part merely moves vertically and towards the right hand, but that only the middle portion is rotated.

The student is advised to get a cylinder such as this made of wood, cut and pinned as in the example.

With such a model he will easily realise the description here given, for if the lower portion be held with the left hand whilst the right hand grasps the upper, moving it in the required directions, it will be seen that only the middle portion will be rotated.

Fig. 659.

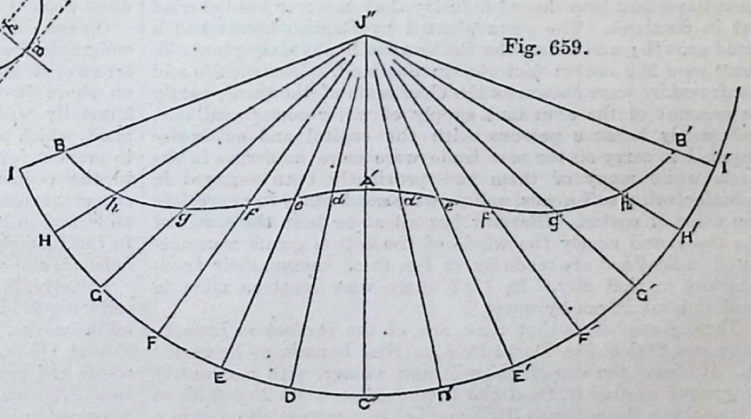


Fig. 662.—To develop this cylinder, divide the plan into any number of equal parts, as shown at A, *b*, *c*, *d*, *e*, *f*, D in the half plan (Fig. 660).

Draw a horizontal line, and erect on it the perpendicular A′.

On each side of A′ set off the divisions *b*′, *c*′, *d*′, *e*′, *f*′, D′, and *b*″, *c*″, *d*″, *e*″, *f*″, D″, taken from Fig. 660.

At D′ and D″ erect perpendiculars, and from B in the elevation draw a horizontal. The rectangle D′ B″ B‴ D″ (Fig. 662) will then be the development of the entire cylinder.

To trace on this development the lines in which the metal is to be cut so that the three parts may be accurately formed without any waste whatever, from *b*, *c*, *d*, *e*, *f* in the plan draw perpendiculars cutting the section lines in *b*′, *c*′, *d*′, *e*′, *f*′. From the points *b*′, *c*′, *d*′, *e*′, *f*′, in Fig. 662, erect perpendiculars, and from the intersections *b*′, *c*′, *d*′, *e*′, *f*′, and E, F, in Fig. 661, draw horizontal lines cutting the perpendiculars in Fig. 662 in E′, *b*″, *c*″, *d*″, *e*″, *f*″, F′. The line drawn through these points will be the curve required. The upper curve is obtained in precisely the same manner, the horizontals being drawn from the points in the line G H of Fig. 661.

To find the true section on either of the two lines, draw lines through the points *b*, *c*, *d*, *e*, *f*, at right angles to G H.

On each side of G H set off on these lines lengths equal to those drawn from *b*, *c*, *d*, *e*, *f*, to A D in the half plan (Fig. 660).

Join these points, and the ellipse thus drawn will be the true section.

Lessons on penetrations of cylinders and their developments will be found in "Projection."

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLII.—DAVID DALE, MANUFACTURER

BY JAMES GRANT.

THIS pioneer of the cotton manufacture, and founder of New Lanark, was born at the thriving little village of Stewarton, on the right bank of the Annock, in Ayrshire, on the 6th of January, 1739.

He was apprenticed to a weaver in Glasgow, and after due time, and gaining the necessary experience in his trade and in business, became a dealer in yarn in that city, and by his application and industry amassed a considerable sum of money, and early became distinguished for his philanthropy, and for that spirit of enterprise which has made the commercial capital of Scotland what we find it to-day.

In 1784 he conceived the idea of founding the large and handsome manufacturing village called New Lanark, situated on the right bank of the Clyde, about a mile above the ancient historical town of the same name, and in the same parish, for the manufacture of cotton. The credit of first introducing the manufacture into Scotland is due to Englishmen. In the year 1778 the first cotton mill was built at Rothesay by an English company, but was not long in being acquired by Mr. Dale, who became one of the most extensive cotton manufacturers north of the Tweed. "The mill," says Mr. Bremner, "was of small extent, and in the present day would be regarded as an almost insignificant concern; but it was the nucleus of one of the most important branches of industry that has ever been carried out in Scotland. The germ planted by English hands had a rapid growth; and before the Rothesay mill was sixty years old, there were 200 cotton factories in Scotland. Lanarkshire and Renfrewshire were chosen as the chief seats of the trade, partly on account of the abundant supply of water-power available, and partly because persons with the capital and enterprise required to carry on the new trade were more numerous in the west, while many of them had previously been engaged in manufacturing soft goods, and so were most likely to appreciate the value of cotton. Glasgow has all along been the centre of the trade, and nearly the whole of the cotton goods manufactured in Scotland are made by, or for, firms having their head-quarters in that city. In 1787 there were nineteen mills in Scotland, all driven by water."

Three years before that time, one of the earliest in Lanarkshire was that of Mr. David Dale at New Lanark, as he named it. He feued the site of the mill and village, with a quantity of ground around it, from the Lord Justice Clerk Braxfield, at a time when the spot was little more than a morass situated in a sloping dell; but the creative mind of the founder saw that it could be turned to greater account by diverting the waters of the Clyde into a power for turning machinery. The first mill was founded by him in 1785, and a subterranean passage of 300 feet was hewn through a rocky ridge for the purpose of forming an aqueduct. In having this dug, Mr. Dale discovered, says the old statistical account, a skeleton of the *Bison Scoticus*, or urus, described in Cæsar's "Gallic War." The cores of the horns, next the head, are fifteen inches in circumference.

The height of the fall of water from this aqueduct is twenty-eight feet. Three years afterwards, Mr. Dale built a second mill, with ranges of houses and cottages for his workpeople. By an accidental fire it was destroyed; but it speedily rose from its ashes, and became, as it is still, one of the most extensive manufacturing establishments in the county.

In connection with another speculator, Mr. Dale established the first works in Scotland for dyeing cotton Turkey red, and was a partner in the manufactory of inkles and tapes. By these means and his own sagacity, he amassed a large fortune, and ultimately became one of the magistrates of Glasgow. The rapid extension of the cotton trade in Scotland was owing, among other things, to the facility with which workpeople could be obtained. There was no regulation requiring special qualification in those who desired employment in the cotton-mills, and generally a few lessons sufficed to make boys and girls, and more especially adults, conversant with the simple duty of attending to the spinning machines or working at the loom. The wages paid exceeded those given to agricultural labourers, and the result was that the plough and spade were relinquished for the cotton mill; a redundancy of hands appeared, and then, the supply being greater than the demand, wages sunk.

About Mr. Dale's mills some 1,400 of the inhabitants of his new village were, and are, constantly employed, and it became a settled rule that no one was to establish himself there, unless employed directly or indirectly about the mills, which are now, perhaps, the most healthy in the United Kingdom. At New Lanark there is none of the confined atmosphere, or other disadvantages which attend similar establishments, created within the crowded localities of our large manufacturing towns. The situation, says a statist, is open, healthful, and pleasant, from its beautiful situation on the Clyde; and the utmost attention was, and is, paid by the proprietors and managers to the cleanness of the dwellings, and the well-being of the people. Until they were ten years of age, no children were allowed to enter the mills, and prior to entry a system of education was compulsory on the parents.

The school which is thus patronised by the company is called the Institution, and by its means "New Lanark has escaped the stigma, which attaches to many other manufacturing communities, of permitting their youth to grow up in immorality and ignorance. The inhabitants, therefore, from this early judicious training, are, in general, an orderly, intelligent, and most creditable class of people, and although originally gathered from many different parts of the kingdom to found the new village, their national characteristics have been merged or amalgamated into a combination which has produced distinctive feelings and habits peculiarly their own." ("Stat. Acct. Scot.")

On one occasion, we are told that, in 1791, a vessel carrying emigrants from the Isle of Skye for America was driven by stress of weather into Greenock, and some 200 persons were put on shore in a very destitute condition. Mr. Dale, whose humanity was ever wakeful, offered them immediate employment, which they gratefully accepted. Soon after, with a view to prevent further emigration to America, he publicly notified to the people of Argyleshire and the Western Isles, the encouragement given to all who were industrious at his cotton-mills, and in 1792 he undertook to erect houses for 200 families. In the following year these comfortable little dwellings were all finished, and occupied by the hardy denizens of the mountains.

Latterly, Mr. Dale, as years advanced upon him, found himself compelled to relinquish the more active management of the mills, works, and village to his son-in-law, the famous Mr. Robert Owen, the propagator of what is called Socialism, and whose visionary notions and projects for a complete regeneration of the state of mankind, by a species of communism, made his name unhappily notorious throughout Britain.

For many years, however, he devoted much attention to the education of the children, and propounded several plans for improving the condition of the inhabitants. These were at first regarded with a friendly eye by those who were used to the philanthropic and almost parental care of David Dale, but have since been deservedly scouted as incompatible with the well-being and framework of social humanity. It is but just, however, to record, that Mr. Owen's name is seldom mentioned by the villagers without respect, and many are the tales and traditions preserved among them of personal kindness and generosity which he displayed in his intercourse with the generation that is past.

David Dale died on the 17th of March, 1806. He was the founder of an independent sect in Glasgow, whose peculiar tenets somewhat resemble those of the Glassites.

MINING AND QUARRYING.—XXXV.

BY GEORGE GLADSTONE, F.C.S.

PYRITES.

IRON PYRITES — GEOLOGICAL DISTRIBUTION — FOREIGN SUPPLIES — ANALYSIS — MAGNETIC PYRITES — CHALCOPYRITE — TIN PYRITES — MISPICKEL — COBALT PYRITES — MANUFACTURE OF ARSENIC — USES — POISONING — ANTIDOTES — MARSH'S TEST.

PYRITES has frequently been referred to in former articles of this series, as well as in Nos. XI. and XII. of "Chemistry applied to the Arts;" but its commercial value will probably be better appreciated, and the distinction between the different

sorts better understood by bringing them all together under one heading.

The name was first given, and properly belongs, to the sulphide of iron, because if one piece is sharply struck by another a shower of sparks will result. But the double or compound sulphides of iron, and some of the other metals, bear a strong external resemblance to that of iron alone, and the use of the term has gradually extended to these also. The commonest of these are copper pyrites, the ore of copper most abundant in this country, and mispickel, the prevailing metal in which is arsenic. Tin pyrites contains both tin and copper as well as iron, and hence is sometimes called bell-metal ore.

Iron pyrites is very widely distributed in nature, being found in geological formations of all ages, even up to the Tertiary, and under almost equally various conditions. It is only recently, however, that it has been turned to much use, as the presence of sulphur prevents its employment in the manufacture of iron in a country which is so abundantly supplied as England is with ores free from that objectionable ingredient. The chief uses are in making sulphuric acid and copperas.

In Cornwall it is termed "mundic" by the miners, and it occurs there in the regular mineral lodes, being a frequent accompaniment of tin and copper ores, especially in those portions of the lodes which are nearest to the surface. If sufficiently rich in mineral, it is dressed and sent to market.

It occurs to an inconvenient extent in many of the coal-beds. In some cases the coal is so disseminated with it as to be rendered almost useless as fuel. A notable instance of this occurs in Staffordshire, where one of the seams is known as the "stinking coal," on account of the disagreeable sulphurous smell which it has, and which becomes stifling when it is burnt. In most of the workable coals, moreover, strings and detached masses of pyrites occur, which are called "brasses" by the colliers, in consequence of their bright yellow metallic appearance. These pieces have to be picked out from the good coal by hand, and are sold in considerable quantities to the chemical manufacturers, who use them principally for making copperas or sulphate of iron.

The upper Secondary and the Tertiary formations often contain pyrites in considerable quantity. It is one of the necessary ingredients of a good alum shale, as may be more fully seen in reference to "Chemistry applied to the Arts," No. XII.; and many of the beds of lias rock, besides that near Whitby which is selected for the alum works, are full of nodules of pyrites, the mineral being generally deposited around some organic nucleus, such as an ammonite or other shell. Some beds of the upper Oolite are highly charged with this mineral, sufficient indeed, in the neighbourhood of Kimmeridge, to have caused spontaneous combustion of the stratum of clay through the heat evolved by the decomposition of the pyrites. In the chalk nodules of it are common, and on account of their sulphurous smell, are supposed, by the country people in many districts, to be thunderbolts! The fossil wood, beds of which are common in the Wealden and Tertiary clays, is generally pyritised, abundant instances of which occur in the Isle of Wight, at Bognor, the Isle of Sheppey, and other places.

These less important deposits have been more particularly referred to, because they are somewhat liable to be overlooked altogether, in consequence of their lying out of the regular mining districts. The consumption of pyrites in this country is now calculated by hundreds of thousands of tons, and while all available deposits on the Continent are sought out to supply our manufacturers, it is a pity to neglect any which might be made available within our own shores.

Almost the only pyrites mines in the kingdom which are worked strictly for the sake of their ore, are those situated in the lower Silurian schists of Wicklow, where the mineral occurs in the massive state. These, together with the Cornish and other British ores, kept all the chemical works supplied up to about sixteen years ago; but the increase in the manufacture of acid has been so rapid of late years that enormous quantities are now imported from abroad.

The principal foreign sources available for our manufacturers are necessarily limited to such situations that the mineral can be brought to this country at a cheap rate. The imports are, therefore, chiefly from Huelva in Spain, Pomaron in Portugal, Hitteren and Stavanger in Norway, and from sundry mines in Belgium and West Prussia. In most of these places the pyrites occurs in such large quantities as to form a solid mass, which is quarried rather than mined. At the Spanish and Portuguese works the mineral is so compact and uniform in its character that the operations can be conducted by machinery instead of requiring manual labour, and the cost per ton of all the necessary operations down to the time of shipment can be estimated to a mere fraction.

In Hildesheim, Hanover, close to the ancient city of Goslar, another very remarkable mass of this ore occurs, but the produce is entirely consumed in the neighbouring village of Oker, which is exclusively devoted to chemical and metallurgical works. The Rammelsberg mine is known to have been worked almost uninterruptedly for the last 900 years, and there seems no prospect at present of its being worked out. The hill rises to a considerable height above the town; the deposit of pyrites commences high up in the interior of the hill, and as it descends it widens out in a wedge shape, which has divided into two branches in the lower levels, but still continues to yield a practically unlimited supply of ore. The mineral is so solid in its character as to yield very sparingly to the ordinary tools of the miner, and a totally different system of mining is therefore carried out here. Timber and brushwood are very abundant on the mountains in the immediate neighbourhood, and they are let down into the mine in very large quantities through one of the upper shafts, which is specially devoted to this purpose, and this is ranged against the walls of ore wherever operations are to be carried on. At the close of the week's work the wood is set on fire and left to burn all Sunday. When the fire has spent itself, and the galleries have cooled down, the miners enter and break away the ore which has been cracked or rendered tender by the heat of the burnt timber.

The chemical composition of the sulphide of iron, FeS_2, would indicate the following per-centage proportions of the two elements—iron, 46·7, and sulphur, 53·3—were the specimen perfectly pure. But the mineral taken in bulk will always contain more or less earthy matters and other metals. The following estimations of the per-centage of the principal ingredients in sundry commercial samples will show what proportions of sulphur and other substances of value should be looked for:—

	Huelva.	Pomaron	Theux, Belgium.	West Prussia.	Hitteren.	Wicklow.	Walker Colliery Brasses.	
Sulphur.	44·6	49·3	45·0	45·6	44·5	44·2	40·5	38·1
Iron . . .	38·7	41·4	39·7	38·5	39·2	40·5	36·3	34·4
Copper .	3·8	5·8	0·0	0·0	1·8	0·9	0·0	0·0
Zinc . . .	0·3	0·0	1·8	6·0	1·2	3·5	0·0	0·0
Coal . . .	0·0	0·0	0·0	0·0	0·0	0·0	17·9	14·4

The rest consists of earthy matter and traces of other minerals, among which the rare metal thallium is found, especially in the Belgian and Westphalian pyrites. The proportion, however, even in the richest of these, does not exceed $\frac{1}{1000}$th part of the whole. The Spanish and Portuguese ores are rather difficult to manage on account of their liability to fuse at the temperature produced by the burning of the sulphur, and a special arrangement of the kiln is necessary so as to afford an unusually large area in proportion to the weight of the charge. These ores contain sufficient copper to enable it to be extracted with profit, which therefore considerably adds to their value. Less than 1 per cent. of copper is not found to be worth extracting. The residue, after the burning of the pyrites in the vitriol works, is generally treated as waste, but it can be used for making iron, provided it is thoroughly calcined, in order to drive off the last traces of sulphur.

There is another combination of iron pyrites which is magnetic. It consists usually of 7 parts of iron to 8 of sulphur, and contains, therefore, 60·5 per cent. of the former to 39·5 of the latter. In some cases the iron amounts to 63·6, leaving only 36·4 of sulphur. It is, therefore, relatively poor in sulphur as compared with the ordinary sulphide, and is not in favour with manufacturers. It is frequently met with in the Cornish mines, as well as in North Wales and Scotland.

Copper pyrites, called by mineralogists chalcopyrite, is the prevailing form in which copper ores occur in this country, and consists of a double sulphide of copper and iron, Cu_2S,Fe_2S_3, yielding 34·5 per cent. of copper, 34·9 of sulphur, and 30·6 of

iron. The mining, dressing, and smelting of it has already been described under the head of "Copper."

Tin pyrites is often found in Cornwall in the search for the usual tin ore, and consists of a mixture of the sulphides of tin, copper, and iron.

A more important is mispickel, also found in no inconsiderable quantity in the same localities. It may be known by presenting the usual crystalline appearance of pyrites, while at the same time it has lost nearly all its usual yellow colour, and appears only of an impure white. It is an arsenio-sulphide of iron, represented by the chemical formula $FeAs_2,FeS_2$, and yielding 46 per cent. of arsenic, 34·3 of iron, and 19·7 of sulphur. It will be seen, therefore, that this is still more deficient in sulphur than the foregoing, and though it is used to some extent in making oil of vitriol, it is of more value as a material from which to make white arsenic. The sulphuric acid made from mispickel is always impregnated to some extent with arsenic, which is objectionable.

Cobalt pyrites consist of a combination of arsenic alone, or arsenic and sulphur, with cobalt. Iron, nickel, and bismuth are often associated to some extent with these ores, so that the analyses will vary considerably. These are used primarily for the sake of the cobalt, and are therefore referred to more particularly in Article XXXIII.

The arsenic contained in the mispickel and the cobalt pyrites is of sufficient importance to be preserved from being dissipated in the atmosphere, where it would exercise an injurious effect on account of its being one of the most active poisons. The manufacture of arsenious acid, the ordinary form in which arsenic is employed, is therefore a trade of very considerable importance, especially in Germany, where these descriptions of ores are much more abundant than in England.

The process of separating the acid from the metals with which it is combined is a simple one, requiring nothing more than roasting in a suitable furnace. This is closed in, and made in the form of a muffle, so that the heat is only derived from the flues which pass all round it. A small fire is sufficient, as it is only necessary just to raise it to a red heat for a time, after which the heat evolved in the oxidation of the charge will help to maintain it during the rest of the process, which usually lasts about twelve hours. The door in front of the muffle is left open during the roasting, so as to supply an abundance of air to oxidise the arsenic, and the floor of the muffle is made to slope a little from the door upwards, towards the pipe which leads to the condensing chambers, so that the current of air shall always set in that direction. The arsenious acid is thus carried through a series of large rooms, connected by openings the one with the other, and gets gradually deposited in the course of its progress. The poison tower, as this pile of chambers is generally called, terminates above in a lofty chimney. The purest acid is condensed in the lowest of the chambers. These are emptied periodically, whenever a considerable quantity has collected, and the acid is finally purified by sublimation.

Arsenious acid is used to some extent in glass-making, to destroy the colour caused by the presence of iron; and also by colour manufacturers and dyers, as the arsenite and arsenio-acetate of copper produce very beautiful greens. Its virulence as a poison leads, unfortunately, to its improper use on some occasions; and the fact of its external appearance bearing a great resemblance to salt or pounded loaf-sugar, has not unfrequently led to its being taken by mistake. The simplest antidote that can be readily procurable in such an event is a liberal administration of calcined magnesia; a large quantity of the hydrated sesquioxide of iron will also render it innocuous by combining with it and forming an arsenite of iron, which is insoluble, and therefore exerts no influence upon the system.

Fortunately there are very simple and delicate tests for arsenic, so that the most minute quantities will not escape detection. The smallest portion of any substance containing arsenic, when heated on charcoal before the blowpipe, will emit such a powerful odour, resembling garlic, that its presence cannot be mistaken; but there are tests much more delicate and conclusive than this.

What is commonly known as Marsh's test can be applied in two or three different ways. The simplest form is that of a common U-tube, the one end of which is drawn out to a point. In the bend of the tube is put some dilute sulphuric acid, some pure zinc, and the article supposed to contain arsenic. If the supposition be correct, a gas will be evolved containing a mixture of arsenic and hydrogen, which can be burnt as it escapes from the pointed end of the tube, by merely applying a light. On placing a plate of white porcelain in the flame the arsenic will be found to leave a residue, which will cause a brownish metallic stain; whereas, if the article tested is free from arsenic, hydrogen only will be evolved, which will not discolour the porcelain.

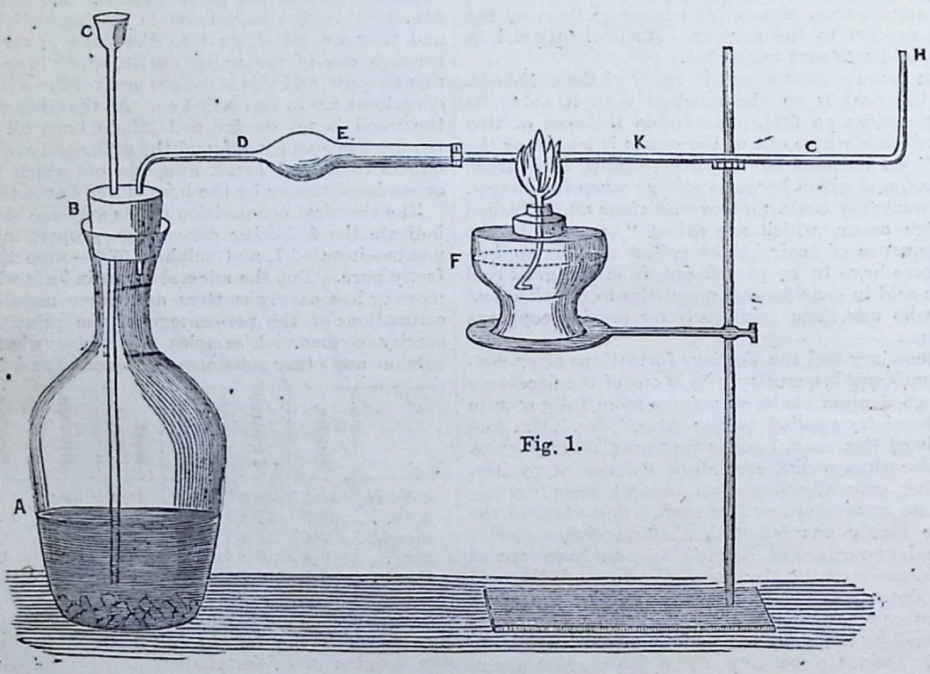


Fig. 1.

The annexed drawing represents an improved arrangement. A is a flask, in which the suspected article is put along with some water and metallic zinc. The apparatus being adjusted, and the cork, B, made to fit tightly, sulphuric acid is poured in through the funnel, C. As the gas is driven off it passes out through the pipe D, the bulb of which, E, is filled with dry cotton wool, to absorb any moisture. Supposing for the moment that the spirit-lamp, F, is not lighted, the gas will pass out through the tube G, and can be lighted at the orifice H, and the test already described can then be applied. But if instead of this the glass tube be heated red-hot by the flame of the spirit-lamp, F, the arsenic in the gas will be separated and deposited in the metallic state in the interior of the tube at K, as the heat at that part will not be sufficient to keep it in suspension. The whole of the arsenic contained in the flask can be collected in this way and afterwards dissolved out and weighed. The chief precaution to be taken is to ensure that neither the zinc nor the sulphuric acid which are used in the test contain any arsenic, a case which is not at all uncommon, but one which is easily ascertained beforehand by trying the experiment first with them alone before adding the suspected ingredient.

COTTON-SPINNING.—II.

By J. Robertson.

CARDING—CARDING-ENGINE—CARDING CLOTHING—EQUALISATION OF THE SLIVERS.

In our last paper on this important branch of one of the greatest of England's industries we gave an account of the first step in the preparation of cotton yarn—namely, that of scutching or cleansing the fibre from dirt and extraneous matter. We will now describe in detail the next process—that of carding. Carding is performed by passing the cotton between two sets of fine wire points which are bent in opposite directions, and which are moved against each other, so that the fibres taken hold of by both at the same time are combed and laid parallel. In olden times this was performed by a pair of hand-cards upon the knee. Towards the close of the last century, however, the inventions of Arkwright, Hargreaves, and others, demanded an improvement in this preparatory manipulation, which had been found totally unequal to the requirements of the increasing trade. Stock-cards succeeded to the hand-cards, and these again were superseded by cylindrical cards, from which, in the first instance, the carded cotton was taken off in short rolls. The cylinder carding-engine has been the object of many important improvements, which have rendered carding one of the most efficient and beautiful of all the operations carried on in the spinning factory. The cotton which enters in the form of a tangled web or fleece, largely impregnated with foreign matter, issues a soft pure ribbon, technically called a *sliver*.

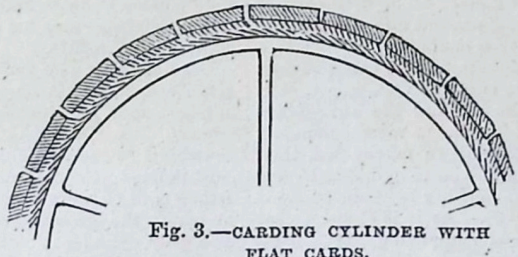


Fig. 3.—CARDING CYLINDER WITH FLAT CARDS.

Fig. 1.—CARDING CLOTHING OF FINE WIRE POINTS FOR FLATS AND ROLLERS.

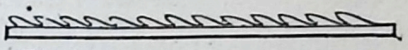


Fig. 4.—SAW-TOOTH FILLETING FOR TAKER-IN.

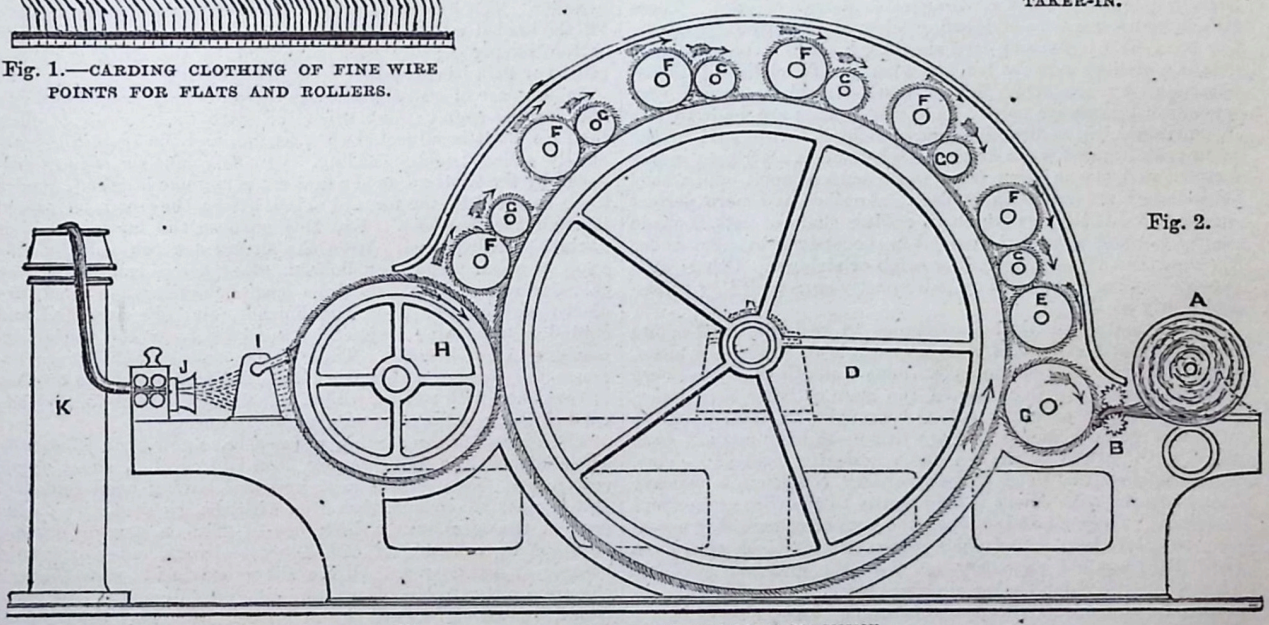


Fig. 2.

Fig. 2.—SECTIONAL VIEW OF CARDING MACHINE.

As in the case of many other machines, opinions differ in respect of some of the details of the carding-engine. The principle is the same in all, and their main features are very much alike. A large iron cylinder thirty-six to forty-eight inches in diameter, and about the same in length, revolving upon a cast-iron frame, is partially surrounded by *flats* or rollers, or flats and rollers combined. All of these are "clothed" with fine wire points fixed in a combination of cloth and india-rubber (see Fig. 1). Formerly these points were set in leather, but the other from its greater elasticity has thrown it almost entirely out of use. These rollers and flats are set as close to the main cylinder as possible without touching. The process of carding may be better understood by referring to Fig. 2, in which a sectional view of the machine that is ordinarily used in carding cotton fibre is represented. It will be remembered that after the operation of scutching is complete, the cotton fibre has been brought into the condition of a thick felted web which is wound up in the form of a bobbin and called a *lap*. This lap which has been brought from the scutching-house is shown at A, resting upon a roller which unwinds it and delivers it without any strain to the fluted feed-rollers, B. So loosely is the web felted that the very slightest degree of tension would tear it asunder. As soon as the cotton has passed the feed-rollers it is seized and carried round by the "taker-in," C, until it in turn is stripped of it by the main cylinder D, the teeth upon which are bent in the same direction at the point of approach, and go at a much greater velocity. Apart from the slight degree of combing which it gives the cotton as it passes the feeding-rollers, the only duty required of the "taker-in" is indicated in its name. This roller is usually "clothed" with a strong coarse card, so that it may be less liable to receive injury from any hard substance which may have passed with the cotton through the scutching-machines, or from its taking hold of matted flakes from the feed-rollers. In some cases this roller is dispensed with altogether for the sake of economy; but it is a short-sighted policy, as the fine points of the main cylinder are very susceptible of damage from the causes mentioned. At E, which is usually called a "dirt-roller," the carding proper commences, the wire upon it being set against the wire upon the large cylinder; and this is the case with all the other rollers, F, at each of which the fibres are held until they are drawn parallel, whilst the broken pieces of shell, leaf, etc., get fixed between the points of the wire, and are either thrown out beneath the machine along with the short staple cotton, or are at regular intervals brushed out by the attendants. These rollers move slowly in the opposite direction from the large

cylinder, so that at the point of approach they retrograde from it. To prevent them from becoming choked with cotton, each of them is brushed or cleared by smaller rollers, G, called *clearers*, having the teeth of the cards bent in the same direction at the point of approach, and revolving much more rapidly. These in their turn again are stripped by the large cylinder, the periphery of which goes at a very much higher velocity. Thus the process of carding and "cleaning" goes on at each successive set of rollers until the "doffer," H, is reached. Here the carding is complete, and the film of cotton which adheres to the surface of the doffer is taken from it by a rapidly reciprocating comb, I. Its appearance now is that of a light, airy cobweb, which is immediately drawn together through a trumpet-mouthed aperture by a set of small calender rollers at J, whence it is taken by the coiler, and coiled and compressed into the can K.

The under side of the main cylinder is commonly cased with a wire grating to prevent any but the shortest fibres being thrown out. A mahogany cover encloses the engine on the upper side, and prevents the dust and short cotton filling the atmosphere of the apartment. This *roller* card is the one most commonly in use. *Flat* cards are, however, largely in favour too, their peculiar feature being that instead of the large cylinder having small rollers surrounding it, the card clothing is mounted upon flat boards or bars of iron (see Fig. 3). As it is obvious that carding can only take place where the opposing cards come together, and as in the case of the roller carding-engine that can only occur seven or eight times when the periphery of main cylinder and rollers touch, it seems reasonable to suppose it to have a disadvantage compared with that which by means of narrow flats can form a continuous semicircle of card. These *flats* in many cases are stripped or cleared at short intervals by the hand with a piece of card sheeting fixed to a board, which entails a greater expense for attendants. To obviate this disadvantage, by rendering the card self-stripping, several very ingenious devices are used. In some the flats are made to rise in succession in a direction perpendicular to the axis of the main cylinder, and when at their highest point a stripper moves forward and cleans them from waste cotton, upon which they immediately return to their place. Another and more perfect arrangement is that by which an endless chain of flats is made slowly to revolve, so that each flat is successively brought under the operation of a reciprocating comb or stripper. Other carding-engines have the main cylinder partly surrounded by rollers and partly by *flats*.

It is a matter of vital importance to keep the card-points well sharpened, otherwise it is impossible to produce a clean, regular fleece. For this purpose once a month or so an emery roller is geared upon the top of the main cylinder and doffer, and after being carefully set and brought to bear upon the wire, the cylinder and roller are driven rapidly against each other, until all the points are made perfectly level and sharp. To maintain them in a proper carding condition, a concave board covered with emery is held gently to the wire at frequent intervals. To grind and sharpen the *flats* or rollers, it is necessary to take them out of their places, and let them run for a short time against an emery roller in the grinding machine. This is generally done every alternate week.

Equally important with the sharpening of the cards is their adjustment or *setting;* that is to say, the cards upon the flats or rollers must be perfectly parallel with those upon the main cylinder, and so close that they almost touch. This is very simply done by means of screws, which raise or lower the rollers or flats in a radial direction. Though sometimes a small slip of thin iron is used in *setting*, by passing it between the two sets of points, yet on account of the flexibility of the wire this is not a safe method. The slip may have passed easily between them, and yet in working it may be found that they are rubbing upon each other. A skilful workman can have no difficulty in dispensing with such a gauge by a careful use of eye and ear.

The seeds and broken leaves which have got fixed between the wires of the main cylinder are stripped out by the hand several times a day. Also the refuse of these, and of *fly*, or short staple cotton, which has gathered below the machine, are removed by attendants from time to time.

The relative speed of the feed-rollers and the doffer is usually as 1 to 100, so that one yard of *lap* is drawn out to one hundred yards of sliver. This *draught* may be increased or diminished by changing the pinions which drive the feed-rollers. The circumferential velocity of the main cylinder is about 15,000 or 16,000 feet per minute, whilst that of the doffer is only about 70 or 80. The carding rollers require to revolve at such a speed as will bring every part of their circumference into contact with the *clearers* sufficiently often to prevent the cotton fibres gathering upon them in too thick a film. The clearers, again, must overrun considerably the carding rollers, so as to clear them out thoroughly.

There are two forms of card clothing for cylinders—viz., sheets and fillets. The former is about four or five inches in width, and of a length suited to the length of the cylinder; the latter is usually about two inches wide, and in length sufficient to cover the cylinder when wound upon it spirally. Filleting is almost universally used now for cylinders and rollers, whilst sheeting is confined to the flats.

Card clothing also varies in the number of wire-points upon a given space, and is designated accordingly. If there are one hundred upon four inches, it is called No. 100; one hundred and twenty, No. 120. These different numbers are made use of according to the particular function of the part upon which the card is fixed. Generally speaking, the taker-in has either a very strong card of a low number or a saw-tooth filleting, as Fig. 4, in which the ground-work is leather instead of india-rubber. The main cylinder is clothed with No. 90 when the cotton being carded is for low numbers of yarn, and with No. 100 or No. 110 when for the finest; the carding roller with No. 90, and the clearer No. 100; whilst the doffer, as a rule, is clothed with filleting about twenty numbers finer than that of the main cylinder. The fine cards enable the reciprocating comb to take off the carded cotton in a finer and more regular web, and the cotton having already been subjected to the carding of the rollers or flats has no power to injure the wire.

In the case of coarse yarns the cotton is only passed through one carding-engine; but when the yarn to be spun is finer than No. 60 it is subjected to a second, and the system is technically called "double carding." In this case the *slivers* produced by the *breakers*, as the first set of engines is called, require to be restored to the form of a lap, before they can be passed through the *finishers*. For this purpose the lap-machine or doubler is introduced. Here the slivers are run side by side upon a wooden spool or bobbin, after being compressed by calender rollers. Two or three large bobbins, when filled, are placed side by side upon the finisher, and are unwound and carded in the same manner as the laps from the scutching-machine in the breaker. There is no necessary difference between the breaker and finisher card, but commonly the breaker is furnished with rollers, whilst the finisher has flats, and the card clothing is ten to twenty numbers finer.

The objects of the carding process have now been effectually accomplished, the fibres having been laid parallel, short staple cotton and fragments of seed and leaf having been removed. But it must be obvious, that even with the greatest care on the part of the operatives, a difference of grist or size, or number of fibres in a section of the different slivers, must exist to a greater or less degree. All the slivers having to pass through the same ultimate operations, any difference in size at this stage would be carried forward to the finished yarn, and thus render it unsuitable for the weaver. To equalise the slivers, and at the same time to straighten the fibres and bring them closer together, is the purpose of the drawing-frame.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLIII.—SIR RODERICK IMPEY MURCHISON, K.C.B., D.C.L., ETC. ETC.

THIS distinguished philosopher was born in Ross-shire in 1792; he was the son of Kenneth Murchison of Taradale, and the great-grandson of one well known in Highland history as the faithful factor of Seaforth, Donald Murchison, who, when the disarmament of certain clans was ordered by General Wade in 1724, sold to that officer all weapons that were useless, while he took especial care that the really serviceable arms of the district—the long-barrelled muskets, the good claymores, the

dirks, skeans, and pistols—were well oiled, packed in tough bull-hides, and concealed in secret places, till King James's son should come to claim his father's kingdom.

Young Murchison was educated at Durham Grammar School, from whence he went to the Military College at Marlow, and in 1807 was appointed to an ensignsy in the 36th or Herefordshire Regiment, with the first battalion of which, under Lieutenant-Colonel Robert Burne, he embarked for the Peninsula, and carried the colours under Moore at the battles of Roleia, Vimiera, and Corunna, and subsequently under Wellesley. He was a lieutenant in 1811, and continued in the service till 1816. Prior to this, on his promotion to the rank of captain, he served on the staff of his uncle, Sir Alexander Mackenzie, with the Sicilian army of occupation.

On the final conclusion of peace he quitted his troop in the 6th or Inniskilling Dragoons, and retired from the service, after his marriage with a daughter of Lieutenant-General Hugonin, and from thenceforward science became the absorbing pursuit of his life. In this new choice he is said to have been greatly influenced by Sir Humphry Davy; but in all his works there lingered traces of the soldier.

So early as 1831, he had applied himself to a systematic examination of the older sedimentary deposits in England and Wales, and after five years of constant labour, succeeded in establishing that which he named "the Silurian system," comprehending a succession of strata that lie *beneath* the old red sandstone, and which seem to approximate to the deposits that preceded the existence of plants and animals. "This system (named from its occupying those counties which formed the ancient kingdom of the Silures) is divided into the Upper Silurian, consisting of Ludlow and Wenlock rocks; and the Lower Silurian, of Caradoc and Llandilo rocks. The same succession of strata was found in the west of Europe, and in North and South America; and Mr. Murchison next traced the extension of the Silurian system to Norway and Sweden, and particularly to the vast empire of European Russia, where the relative position of the older rocks has suffered little or no disturbance from the intrusive agency of fire." Prior to this, in the year 1825, he had become a member of the Geographical Society.

Under the countenance of the Imperial Government, in 1840, with Count Keyserling and De Verneuil, he entered upon a work which gradually extended until it had embraced important observations in nearly every portion of Russia, Poland, Germany, and Scandinavia, being a scientific expedition equalled only by those of Humboldt in South, and of Lyell in North America. The result of this learned tour was the foundation of "the Permian system," the uppermost member of that great Palæozoic series, which, as Professor Phillips says, "owes to Sir Roderick many of its foundation-stones." An account of the expedition was published in two large volumes in 1845. In 1841, on the presentation of the first report to the Emperor Nicholas, he gave Mr. Murchison the second class of the Order of St. Anne in diamonds, and a magnificent colossal vase of Siberian avanturine on a column of porphyry; and three years later, on his completion of the Russian survey, he received the Grand Cross of St. Stanislaus, and was made a member of the Imperial Academy of Sciences. Upon his return to Britain he was knighted by her present Majesty.

The importance of his geological discoveries will be better understood by the reader when he is told that they led to the consent of geologists to form the principle "that it is by groups of associated organic forms, indicating life periods, that the chronology and sequence of the rocks and their remains are to be estimated."

It was with sensations of very great disgust that Sir Roderick saw his facts—which led the chain of life from the Azoic rocks up to the world of man—laid beneath such sceptical superstructures in Germany, as those with which Britain became familiar in the work entitled "Vestiges of Creation."

In the year 1844, when bringing out his large work on "The Geological Structure of Russia," he instituted a comparison between the rocks of Eastern Australia and those of the auriferous Ural mountains, and this led him to the conclusion that gold must exist in that quarter of the world. So convinced was he of the correctness of his hypothesis, that in 1846 he even urged some Cornish miners to emigrate to New South Wales, there to obtain gold from the rich alluvial soil, in the same manner in which they extracted tin from the gravel of their native country.

In 1848, he addressed Earl Grey, then Colonial Secretary, to the end that Government might adopt measures for the interests of the Crown; but his advice was not taken, and it was only in 1851, three years later, that the so-called *discovery* of the gold-fields in Australia took place.

In 1849, when, as a tardy recognition of their services, the war decoration was granted to the surviving officers of the Egyptian and Peninsular armies, Sir Roderick received a silver medal with three clasps for Roleia, Vimiera, and Corunna.

He was four times President of the Geological Society, and fourteen years President of the Royal Geographical Society. He was a member of the Royal and Linnæan Societies; member of the Academies of St. Petersburg, Berlin, Brussels, Copenhagen, Stockholm, Turin; and was long a Trustee of the British and Hunterian Museums, and of the British Association for the Advancement of Science, of which last body he was one of the founders.

It was in his capacity as President of the Geographical Society that he first became acquainted with his countryman Dr. Livingstone, his devotion to whom, and furtherance of whose schemes for the exploration of Africa, have been so unwearied. During their career, few men of science have met with so full a recognition of their services as Sir Roderick Murchison.

In 1855 he succeeded Sir H. De la Beche in the office of Director-General of the Geological Survey of the British Isles; and his latest labours have been repeated examinations of the volcanic rocks of his native Highlands, for which the Royal Society of Edinburgh conferred upon him their first Brisbane or gold medal. The Copley medal, or first honour of the Royal Society of London, was awarded to him in 1846; and from an early period he held the honorary degree of M.A. of the Universities of Cambridge and Durham. He also held the diplomas of D.C.L. and LL.D. In 1866 he was created a baronet of the United Kingdom.

In the foundation of the Permian system, he had at first indicated less facility for the reception and adoption of new facts and ideas than his friend Sir Charles Lyell, author of so many well-known geological works; but the younger discoverers remembered that the venerable Murchison had been also a theoretical pioneer in his day; and though they at times thought that he had become so identified with the Silurian period as to look upon its sceptical critics with pain, they never failed to award him their esteem, respect, and affection.

He has taken his place with Buckland, De la Beche, and Lyell as a father of British geology; he has received the homage of nearly every foreign scientific society, and his name has been bestowed upon the Murchison river in Western Australia, on a great mountain in New South Wales, and upon a strait at the head of Baffin's Bay, the entrance of which was long known to navigators as Whale Sound. It has also been given to other places in British North America, in Greenland, and in India. But with Australia his name is most popularly associated, since it was he who first predicted that its soil was full of gold.

"Personally," says a writer, "Sir Roderick was most esteemed by those who knew him most intimately. He has never failed, by advice or pecuniary means, to aid any man of ability who desired to pursue his studies or discoveries, and many a youth in England has reason to remember him as a generous benefactor. He was free from jealousies and full of personal enthusiasms. None who were present at the meeting of the British Association at Bath in 1864 will forget the serene joy with which Sir Roderick sat by his friend Livingstone, or the emotion with which he gave the thanks of the Association to Sir Charles Lyell for his address. When he alluded to the recent honour of a baronetcy which Her Majesty had bestowed upon Sir Charles, he was most eloquent, and sat down amid loud plaudits. Faults of manner he may have had, and there are faults in his statements of theoretical geology; but it is very certain that since the time when Voltaire imagined that the shells of Geneva had been dropped from the wallets of pilgrims, the knowledge of the vast changes the world has undergone has advanced in rapidity, as some think, beyond any other knowledge, much of the honour is due, where it was bestowed, on Sir Roderick Murchison."

Prior to his giving to the world his Silurian system, the rock-

history of the earth was but little known, and the strata beneath the old red sandstone formation had been "a scientific No Man's Land;" and it was in 1851, when defending his theory in an address delivered at the Royal Institution, on the former changes of the Alps, that he ended an impressive statement of the evidences, showing that there had been a succession of creations from lower to higher types of life, in the ascension from inferior to superior geological formations; and he denounced the "Vestiges of Creation," and the whole theory of the transmutation of species, with great warmth and in forcible language. And to these views he held, even after the former theory had passed into the doctrine of evolution as held by Dr. Charles Darwin.

In recent years, Sir Roderick made a great addition to British geology by establishing in the north-western Highlands of Scotland the existence of the fundamental stratified deposits of the United Kingdom, these, the so-called Laurentian rocks, being still older than the Cambrian and Silurian systems.

In 1863 he was made Knight Commander of the Bath, and in the following year he received the Prix Cuvier from the French Institute, and the Wollaston Medal at home, for his geological labours; and his love of study and enthusiasm in the cause of science were unwearying, and ceased only with the end of his long and useful life.

He died on Sunday, the 25th of October, 1871, at his town residence in Belgrave Square. He expired about half-past eight in the evening, and in the seventy-ninth year of his age.

CIVIL ENGINEERING.—XXIII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

THE finest timber bridge which was probably ever constructed, whether for length of span, or for lightness and elegance in construction, was that built over the Schuylkill at Fairmont, U.S., by Wernway, and destroyed by fire in 1838. It consisted of a single arch, having a span of 340 feet clear from one abutment to the other. Fig. 63 shows a side view of this bridge.

Its versed sine was 38 feet, and the breadth of the carriageway 30 feet. To ensure the internal soundness of the timber, every piece of large dimensions was sawn through the middle. The main ribs were laid three deep, and strongly bound together with wrought iron. The king-posts were twenty-nine in number, radiating from the centre of the circle of which the arch formed a portion. These were kept in their respective positions by timbers fixed between their heads, and further secured by diagonals or struts which served the double purpose of fixing the king-posts more securely, and of preventing the arch from springing. The abutments were of solid masonry. The floor or roadway rested upon girders which were laid upon shoulders formed in the sides of the king-posts, and securely bolted to them. Tie-beams extended across the roof of the bridge from the heads of the opposite king-posts, by which these important timbers were yet more entirely secured, serving at the same time to support the roof, which was of light construction. The sides of the bridge were closely boarded in.

The timber employed in the construction of bridges requires to be regarded in a different manner from that used in more solid structures, since in the former case it is subjected to many varieties of strain, the strain being irregular. The passage of carriages produces a constant vibration, and this vibration, although communicated to the entire bridge, is yet more severely felt in the part immediately influenced. The natural elasticity of timber causes it to bend to a certain extent under a passing load, and to recover itself after the load has passed; but this constant action is prejudicial to the elasticity and flexibility of the material. For this reason, every precaution must be adopted to render the framing as rigid as possible, and by a frequent and proper application of paint, pitch, or other material, the destructive effects of the alternations of dryness and humidity should be prevented.

In selecting timber for engineering purposes, it must be borne in mind, that although in the growing tree the heart is the strongest portion, yet that after the tree has attained maturity, decay commences in the interior, and that, therefore, the exterior portions will generally be found the most reliable. Above all things the least sign of decay in a piece of timber must be eradicated. Too much care cannot be used in this respect, for, like a disease, it will spread itself slowly but surely throughout the entire piece, and will even communicate the destructive action to adjoining pieces.

The choice of the timber for a structure must depend very largely upon local considerations, as the cost of carriage will often preclude the employment of the most suitable kind. Amongst those kinds which are of the greatest value to engineering structures, the oak and the fir rank highest. The former from its hardness is difficult and expensive to work, but its great durability renders the first cost a matter of less moment. In submarine structures especially, the advantage of employing oak is apparent, as it will endure under water for an unknown period. There are several kinds of oak, and its specific gravity varies according to the soil in which it grows. Its strength is proportionate to its density, and that timber is the most durable whose density is the highest; but the density being chiefly due to the length of time occupied in the production of the wood, it follows, that the colder the soil, and therefore the slower the growth of the tree, the better is the timber.

The specific gravity of oak varies from 1·000 to 1·054, and its weight per foot cube from 70 to 74 lbs. When properly seasoned, the weight will become reduced from 60 to 63 lbs. It may be yet further reduced by drying, but it is found undesirable to push this too far, and as a general rule it is in its best condition for the purposes of building when it has lost about one-sixth of its original weight.

The expensive character and limited quantity of good oak renders it desirable to find a substitute, and in no timber have we a better, all things being considered, than good sound fir. The best fir timber is obtained from the Baltic coasts, and its lightness and stiffness render it very desirable for girders and framing generally. The same rules with regard to quality hold good in the case of fir as of oak—slowness of growth; and this slowness is best ascertained from the annular rings, which should be thin and close together. The trees are usually sawn up into deals of three inches thick, but they may be had in the bulk as thick as 12 inches.

Timber for engineering purposes should be cut at the fall of the year, that is, when the sap has retired from it; and it should not be used until after at least six months' constant exposure either to wet or dryness, and the bark should have been removed three months before using. The principal strain and thrust should always be thrown upon the end grain of the wood.

The weight that will break a piece of timber must be ascertained before we can find the load it ought in practice to have placed on it; and as a safe rule, the deflection of a beam supporting a lateral weight should never be allowed to extend beyond $\frac{1}{480}$th part of its length, or $\frac{1}{40}$th of an inch to a foot of length.

It is most desirable in employing timber for any structure, but more especially for a bridge, to ascertain the direction and amount of strain it will be subjected to. The *parallelogram of forces* becomes one of the most valuable rules for the guidance of the engineer in all structures consisting of beams. This remarkable law, which governs the equilibrium of any three forces of whatever kind, may be stated as follows:—*If three forces acting upon a point are in equilibrium, and lines be measured from this point in the directions of the forces, so as to contain each a given unit of length as many times as there are units in each force, then these lines will form the adjacent sides and diagonal of a parallelogram.*

From the point A (Fig. 64) let the two lines A B, A C be drawn, of which A B shall consist of five units of length, and A C of ten such units, the lengths representing the amount of force applied; complete the parallelogram A B D C; then the diagonal A D represents the *direction*, and its length the *amount* of strain exercised by A B and A C at the point A.

From this law it follows, that whatever be the number of forces acting upon the point A, we may replace any one of them, A D, by two, A B and A C, into which it is resolved; and conversely, we may replace any two of them, A B and A C, by their resultant A D; and further, when we know the directions of the three forces which hold a point at rest, and the magni-

tude of one of them, we can determine the magnitudes of the other two forces.

Rectangles have their centres of gravity at the intersection of the perpendiculars let fall from the middle of adjacent sides; a piece of timber 10 × 10 contains in its section 100 square inches, and its centre of gravity will be five inches from each side. If the piece be broken by a lateral force, its fracture will terminate at the *upper* surface, or five inches above its centre of gravity. The area 100 × 5 = 500 gives us its lateral strength. This may be regarded as a rule with respect to lateral thrust. For instance, if the above piece of timber be sawn through the middle of its length, we obtain two pieces 10 × 5 giving each a section of 50. Multiply this by 5, which is the distance of the centre of gravity from the *top* side, and we obtain 250, or half the lateral strength the beam previously possessed. But now turn the same half beam on its flat side. Then 50, its sectional area multiplied by 2·5, the distance of the centre of gravity from its *upper* surface, and we obtain only 125, or just one-half the lateral strength the beam possessed when laid on its edge. From this fact we learn the value of placing timbers, such as flooring joists, upon their edges, in order to utilise to the utmost their strength. It will be seen also by the above that timbers possessing the greatest section may, by an unwise application, be of less absolute value, as regards the work they have to do, than timber of less scantling properly applied, affording another instance of waste of material. Thus, a piece of timber 8 × 6 has an area of 48 inches, and a piece 7 × 7 contains 49 inches; but the strength of the former placed on its edge is 8 × 6 × 4 = 192, whilst that of the latter is 7 × 7 × 3·5 = 171·5 only. From the same rule, we learn that a piece of timber whose cross-section is that of an equilateral triangle is, when subjected to lateral thrust, twice as strong when resting on its base as when placed on edge, because the centre of gravity is only $\frac{1}{3}$ of its height measured from its base, but $\frac{2}{3}$ from its apex. In a cylindrical beam the lateral strength is as the cube of the diameter. A piece of timber of the greatest strength that can be cut out of a round tree is obtained by dividing the diameter of its section (see Fig. 65) into three equal parts, A, B, C, raising perpendiculars upon these points to the circumference, and uniting the points of intersection by the lines D E, E F, F G, G D. The rectangle so obtained will form the strongest beam obtainable from the tree.

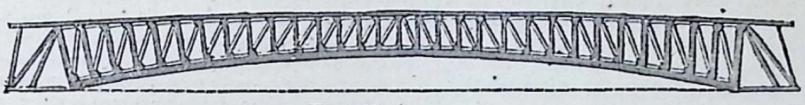
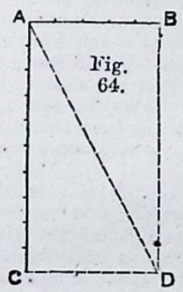


Fig. 63.



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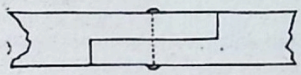


Fig. 67.

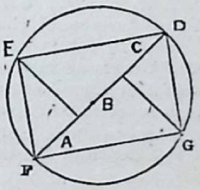


Fig. 65.

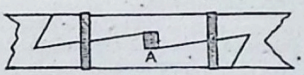


Fig. 69.

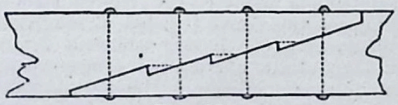


Fig. 68.

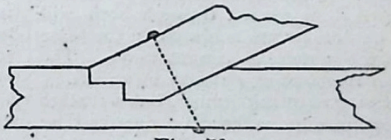


Fig. 70.

If a beam be supported at one end only, and loaded at the other, the weight so placed exercises four times the amount of strain it would supposing it were suspended in the middle and the beam supported at both ends, and a weight uniformly distributed over a beam exercises a tendency to break it, of only one-half of what it would if concentrated in the middle.

Suppose s to represent the weight requisite to break a piece of timber whose length, breadth, and depth are each 1 inch, and let l represent the length of some other beam of a similar wood in inches, b = its breadth, d = its depth, and w the weight that would break it; then if a beam be fixed at one end, and loaded at the other, $w = \frac{s\,b\,d^2}{l}$; if the beam be fixed at one end, and loaded uniformly throughout, $w = \frac{2\,s\,b\,d^2}{l}$.

If a beam be supported at each end, and loaded in the middle, $w = \frac{4\,s\,b\,d^2}{l}$; or if a beam be supported at each end, and loaded uniformly throughout, $w = \frac{8\,s\,b\,d^2}{l}$; and if a beam be fixed at one end and loaded in the middle, $w = \frac{6\,s\,b\,d^2}{l}$. These formulæ become of value when the cohesive strength of various kinds of timber has been determined. We give a few in the following table, the value having reference to a cube of one inch:—

Beech	1,556	Fir, Memel	1,635
Chestnut	1,350	,, Norway	2,376
Elm	1,620	,, Scotch	1,746
Ash	2,355	,, Larch	1,896
Oak	1,672	Mahogany:—	
Teak	2,151	,, Spanish	1,275
Fir, Riga	1,590	,, Honduras	1,911

To apply the formulæ given, to the table of values, suppose it to be required to ascertain the breaking strain of a beam of Norway fir 10 feet long and 10 inches square, supported at both ends, and the weight uniformly distributed; then $w = \frac{8 \times 2376 \times 10 \times 10^2}{120} = 158{,}400$ lbs.; or if the weight be applied to the beam in the middle only, $w = \frac{4 \times 2376 \times 10 \times 10^2}{120} = 79{,}200$ lbs. By the same rule, a beam of Scotch fir will support respectively only 116,400 lbs., and 58,200 lbs. under similar conditions to the above.

It is a safe rule to adopt, not to load a piece of timber beyond one-fourth of its breaking strain.

The resistance to compression in the direction of the length of a piece of timber is not always equal to the power that would tear it asunder. Timber with a cross-grained fibre, such as oak, offers less resistance to compression than timber with a straight grain; hence, a fir-post is capable of supporting three times as great a weight as one of oak, although, as a tie, oak will be the strongest. The relative strength of timber against compression is as the cube of its diameter directly, and inversely as the square of its length. The stiffest post is that whose sides are to one another in the proportion of 10 to 6.

The length of a post is a matter of more moment than might at first sight appear, even though the weight be applied on the end, and the beam stand perfectly vertical. Experience has shown that if a vertical post be more than seven or eight times the width of its base, it will bend under the weight applied before it will crush. Both oak and fir beams become diminished in strength when their length is such that they will bend rather than crush. Rondelet ascertained by experiment that the mean strength of oak for supporting a weight was 47·52 lbs. avoirdupois for a cube of $\frac{555}{1000}$ of an inch: and if we take the strength of a cube of 1 = 1, the strength of a post whose height is 12 times its base = $\frac{5}{6}$; one of 24 times = $\frac{1}{2}$; one of 36 times = $\frac{1}{3}$; one of 48 times = $\frac{1}{4}$; one of 60 times = $\frac{1}{12}$; and one of 72 times = $\frac{1}{24}$. These are important considerations in the arrangement of beams, and it leads to the conclusion that no beam unsupported laterally should be greater in height or length than about 10 times its diameter at the base, supposing the force be applied as a thrust at the extremity.

When a beam becomes inclined from the perpendicular, its strength to support a weight applied vertically diminishes in proportion to its angle of inclination. Let A B (Fig. 66) be a beam standing vertically at B, then suppose it inclined in the

direction C B; let fall the perpendicular C *b*; then the weight applied vertically at C which C B can support will = C *b* = the sine of the angle of inclination. As C moves towards A, the length of C *b* will increase, and at A will = the radius. Hence the rule, that the strength of a piece of timber standing vertically, is to that of a piece of the same dimensions inclined as A B to C *b*, or as the radius to the sine of the angle of inclination.

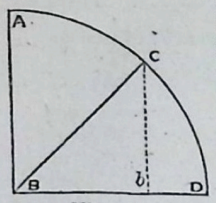


Fig. 66.

Owing to the difficulty of obtaining beams of great length, such as are constantly required for bridge-work, it is necessary to adopt some method of uniting them firmly at their extremities, so as to resist every kind of strain which may be applied. This joining process is termed *scarfing*.

The simplest joint is that known as *ship-lapping* (Fig. 67), in which each end is cut down through half its thickness, and the cut met by a cross-cut, and the piece removed. The two ends being similarly cut will unite with a flush-joint, and are secured by trenails or bolts. This makes a neat joint, but it will not bear a strain, only a thrust.

An ordinary scarf is shown in Fig. 68, and consists in cutting notches in the inclined surface given to the ends of each beam, so that they shall fit into each other; their connection being retained by two or more bolts. Such a joint will sustain an amount of strain equal to the actual crushing strength of the timber contained in the notches, and bounded by the horizontal dotted lines, supposing the grain of the wood to run with the length of the scarf.

Another form of scarf is shown in Fig. 69, in which a joggle of hard wood, A, is driven into the centre of the scarf, the ends of which are dovetailed. Such a joint is not altogether dependent upon a bolt driven through, as in the preceding, but is improved by a band of hoop iron placed around it.

The length to be given to a scarf must depend upon the cohesive force of the timber. A safe rule is to make that from oak, ash, or elm, six times the depth of the timber; and that for fir, twelve times the depth.

When timbers have to be united at an angle—as, for instance, in the union of the principal rafter with a tie-beam (Fig. 70)—the lower beam should be notched as shown, and the end of the rafter cut to correspond. A bolt passed through both will keep it in its place, and as the thrust is always in the same direction—namely, against the notch—it cannot move. The character of the notch and corresponding cut may be varied.

Much more might be said respecting timber, but a further consideration of the subject belongs rather to carpentry than engineering, and we refer our readers to "Building Construction" and the early papers in "Technical Drawing" for further information. One general remark is, however, necessary, and that is, that as all timber is liable to expansion and contraction, care must be taken in making joints to allow for this.

SEATS OF INDUSTRY.—XXXVII.

BOMBAY.

BY WILLIAM WATT WEBSTER.

The most important centre of commerce in our Indian empire certainly deserves a place in this series of papers, not only on account of the intrinsic interest attaching to its history, but also because it fairly illustrates what British trading enterprise has accomplished in other Eastern towns. Bombay stands on an island of the same name, which was formerly separated into several smaller islands, but many acres of land once under water have been recovered, and the two ranges of hills that cross it have been united by fertile valleys. It is the capital of the Presidency of Bombay, which has an area of 137,743 square miles, and a population estimated at over 20,000,000. The city is very advantageously situated for the prosecution of commerce, but the greater part of the site on which it is built is low-lying and swampy, and previous to the construction of an expensive system of drains and embankments, it was very unhealthy.

It is not necessary to our purpose to trace the history of Bombay farther back than the year 1530, when it was transferred to the Portuguese by an Indian potentate. In 1661 the Portuguese ceded the island to Charles II. as part of the dowry of Queen Catherine; but the Portuguese governor having refused to deliver it up, it had to be besieged with heavy loss before it came into actual possession of the English in 1664. It is very curious to note what was thought of this new acquisition by the English politicians of the time, who, if we may judge from an entry in Pepys' "Diary," scarcely considered it worth having. "It seems strange to me," he writes under date 1663, "that such a thing as this, which was expected to be one of the best parts of the Queen's portion, should not be better understood; it being, if we had it, but a poor place, and not really so as was described to our king in the draught of it, but a poor little island; whereas they made the King, and Lord Chancellor, and other learned men about the King, believe that that and other islands that were near to it were all one piece." We need not wonder that Mr. Pepys' failed to foresee the value that this "poor little island" would acquire in the future. In 1668 the city and island were handed over to the East India Company, and at this date the population consisted of about 10,000 natives and a few Portuguese and Englishmen. Bombay was used at first by the East India Company only as a military station, and it was here that the first companies of native troops which formed the nucleus of the famous Sepoy army were trained under English officers. Up till 1686 Surat was the seat of the Indian Government, and the commercial head-quarters of the East India Company, but in that year the Company removed to Bombay. Owing to the protection afforded by the troops, native cotton-spinners, weavers, and merchants, crossed over from the mainland and settled on the island, and the manufacturers of Bombay soon acquired some special privileges. In 1670 Bombay was besieged by the Mogul, who only withdrew in the following year in obedience to the orders of Aurungzebe. Under the government of the East India Company the native population of the island rose in a few years from 10,000 to 60,000, and by the end of the seventeenth century Bombay was the principal centre of English commerce in India, and it has retained its pre-eminence ever since.

From the time of Alexander the Great till the destruction of their strongholds in the Arabian and Persian Gulfs, in 1819, formidable bands of pirates infested the Malabar coast, and the trade of Bombay suffered long from their depredations and the check they gave to enterprise. Plague and rebellion also devastated and disturbed the colony for many years. In 1788 Aurungzebe the Great invaded Bombay, and the East India Company, not then having sufficient forces at command to repel the assault, averted the danger by liberal payments of money to their assailants. But notwithstanding the numerous and great obstacles it had to contend against, Bombay made steady and rapid progress, no small portion of its later prosperity being due to the Parsees, who settled in the city in large numbers, and made it their adopted home. This enterprising race are not only proportionally more numerous in Bombay than in any other town in India, but they constitute a very wealthy and influential section of the community. The greater part of the island belongs to Parsees, and there is scarcely a European house of business in Bombay in which a Parsee has not a share, and in general the Parsee is the largest capitalist. Descendants of the Ghebers, driven out of Persia by Shah Abbas, the Parsees are not less remarkable for the mildness of their manners, than for their intelligence, perseverance, and success in the pursuit of wealth. Although their women enjoy more liberty than the Hindoo and Mahometan women, they are the chastest in India; indeed, it is said, that no woman belonging to the sect has ever been known to be a courtesan. The Parsees provide for their own poor; and although devotedly attached to their religion and customs, they eat, drink, and hold the freest intercourse with Europeans. The whole of the northern quarter of Bombay is occupied by this sect, and in every department of trade connected with the docks and shipping they have the chief interest. It was a Parsee family named Lowji who first introduced ship-building into Bombay in 1735, and the same family has remained at the head of that industry, which is principally carried on at this port by men of the same race, ever since. Not only have vessels for the Indian navy been constructed by Parsees in the ship-building yards of Bombay, but many large imperial men-of-war have also been built there. The country-houses of the wealthy Parsees are furnished with

the richest European decorations, and their owners are famous for their public spirit and the munificence of their benefactions. Among the charitable institutions of Bombay the Jamsetjee Hospital and the Jamsetjee Obstetric Hospital take high rank, and these hospitals were founded and endowed by a member of a Parsee family which is highly honoured in England as well as in India. Indeed, few merchant princes in the world have acquired a higher or more wide-spread reputation for enterprise, integrity, and patriotism than Sir Jamsetjee Jeejeebhoy of Bombay.

In addition to their charity, which seems to be an inherent quality in the Parsees, they exhibit a marked tolerance to the opinions and religious views of others. There are many temples for the adoration of fire in the city, and morning and evening the whole of the male Parsee population betake themselves to the esplanade and worship the sun. In these rites the females take no part, but, as in ancient times, the Parsee women of all ranks continue to carry water from the wells. Among the strange customs of this sect is the exposure of their dead to be devoured by vultures in buildings left open at the top to admit the ravenous birds. Being regarded as aliens both by Hindoos and Mahometans, and being enthusiastic traders, the Parsees have all along been favourable to the English power, and from the earliest times they have proved themselves valuable and reliable auxiliaries.

THE LATHE.—XIV.

By Henry Northcott.

SELF-ACTING LATHES (*continued*).

The overhead shaft carries a coned pulley for driving the lathe-pulley, and two sets of three or altogether six other pulleys. But one set of pulleys is of much smaller diameter than the other. When the lathe-spindle is in motion and geared with the leading screw so as to drive the slide-rest along the lathe-bed, the traverse of the tool is usually slow, and if the lathe be employed in cutting a screw with a right-handed thread, the direction of the traverse will be towards the cone headstock; that is to say, when the lathe is employed upon its ordinary work of plain cylinder turning and right-hand screw-cutting, the tool is caused to travel along the work from right to left, or from the screw headstock to the cone headstock. When the tool has travelled to the end of its cut, the slide-rest has to be run back again towards the right, in order that another cut may be commenced. For plain cylindrical turning the practice is to run the slide-rest back by means of the large traverse handle in front, first of all slightly withdrawing the tool from the work, so that its point may not scratch against the surface, and also unclasping the nut from the leading screw. All this is done without stopping the lathe. But when the lathe is employed in screw-cutting the tool runs faster, and if the screw be short, it is not worth while to run back the rest by hand, as by reversing the lathe the saddle is run back by the screw almost as fast. For long screws there would be a saving of time by using the hand-traverse motion, were it not for a practical difficulty in getting the tool to start always from the right place. Owing to this difficulty, it is generally preferable to run the tool back by reversing the lathe rather than to run it back by hand, even though a little more time be occupied by the journey. The mode in which the overhead or counter-shaft is driven from the main shaft has been explained, and to drive the lathe in the opposite direction to the usual one it is only necessary that the overhead shaft shall be driven from the main shaft by a crossed belt instead of by the straight one. And to have the power of driving the lathe in either direction, there must be both a straight and a crossed belt with provision for shifting either of them on to the fast-pulley of the overhead shaft. This obviously entails the necessity of having two loose-pulleys, and one fast-pulley placed between them. These three pulleys would necessarily be of the same size, and the lathe would be driven at the same speed both forward and backward. In order, therefore, to reduce the time spent in running the tool back, good lathes are frequently furnished with two sets of pulleys of different sizes. The small pulleys are driven by the crossed belt, and the large ones by the straight belt. With this arrangement, the reverse motion of the lathe is much faster than the forward motion, and the tool is consequently run back towards the screw headstock in one-half or one-third the time employed in its forward or cutting journey. A lathe fitted with a quick return motion is enabled to turn out more work, and the hand-traverse saves no time even for the longest screws.

Fig. 102 is a light screw-cutting lathe by Messrs. Whitworth and Co., of Manchester. The leading screw is placed inside the bed, and is driven from the lathe-spindle by the change-wheels seen at the end. This position of the screw is adopted by some machine-tool makers in preference to that of outside the bed, and it has some advantages, but at the same time it introduces complications and inconveniences which render the arrangement anything but an unmixed advantage. The intermediate change-wheels are carried upon studs fastened to a double-slotted plate, radiating round the centre of the leading screw, and hence termed the radial arm. The mode of calculating and arranging these wheels will be hereafter explained, but the function of the radial arm will be apparent from the several illustrations.

A pile of the change-wheels is shown standing behind the lathe, and on the bed is a hand tool-rest, and a very useful instrument called a boring collar. On the ground will be seen the counter-shaft with its pulleys, supporting brackets, and belt-shifting slide; also a small drill chuck, a face-plate, an eight-screw chuck, and a four-jawed chuck. These are all indispensable instruments to a lathe of this sort, the four-jawed chuck being invaluable. Fig. 103 is another excellent specimen of a lathe by Messrs. Fairbairn, Kennedy, and Naylor. This one is both self-acting and screw-cutting, and the automatic mechanism is also applied to the surfacing-slide of the rest. It is always advisable to have the bearings for the spindle as wide apart as possible, as its centrality is not so liable to be affected by wear, and the headstock should be made sufficiently strong to prevent the possibility of any springing or yielding against the pressure to which it is necessarily subjected. The cone-pulley of this lathe has four steps or speeds, and good strong back-gearing. The wheels are thrown into and out of gear by an endway motion of the spindle, upon which the back wheel and pinion are hung. A face-plate is shown in place upon the spindle-nose, whilst the eight-screwed chuck and the driving-plate are lying on the ground in front with the overhead apparatus, which, it will be observed, has the double set of pulleys for getting a quick return of the tool. The position and arrangement of the change-wheels are very clearly shown in this illustration. A small pinion on the end of the lathe-spindle gears into a large wheel in the intermediate stud, and a pinion on the same socket as this wheel gears into a larger wheel placed upon the end of the leading screw. The leading screw would consequently, under this arrangement of wheels, be driven much slower than the spindle itself. So far as the direction of the motion of the leading screw is concerned, a pair of intermediate wheels on the same axle or socket act as one wheel, and a pinion on the lathe-spindle driving a wheel on the leading screw will move the slide-rest from right to left, or in the direction necessary for cutting a right-hand spiral.

Sometimes, however, screws are required to have left-hand spirals, and to produce these the tool must move along the work in the reverse direction, or from left to right. This reversal of the direction of the tool's traverse is brought about by the introduction of a second intermediate wheel between the pinion on the lathe-spindle and the leading-screw wheel. The position and size of this second intermediate is a matter of no consequence, nor does it affect the speed of the leading screw in any way. If, therefore, the wheels be arranged with one intermediate wheel or two on one stud, to give such a number of rotations to the leading screw as will cause the tool to describe a right-handed spiral on the work of, say, one turn to the inch, the introduction of another wheel of any convenient size anywhere into the train of change-wheels will, by reversing the direction in which the leading screw rotates—the direction of the lathe's rotation remaining the same—cause the tool to describe a left-handed spiral of the same pitch as before.

Generally, the second intermediate wheel with its stud forms quite a separate part of the lathe, and it is only attached to the radial arm when the reversed traverse is required, which is not very often. But some lathes are constructed with a reversing wheel placed in position upon a swing-plate, so that it may be thrown into the train by merely raising a handle. This arrangement is convenient in some respects, but its merit is not such as to cause it to be very often adopted.

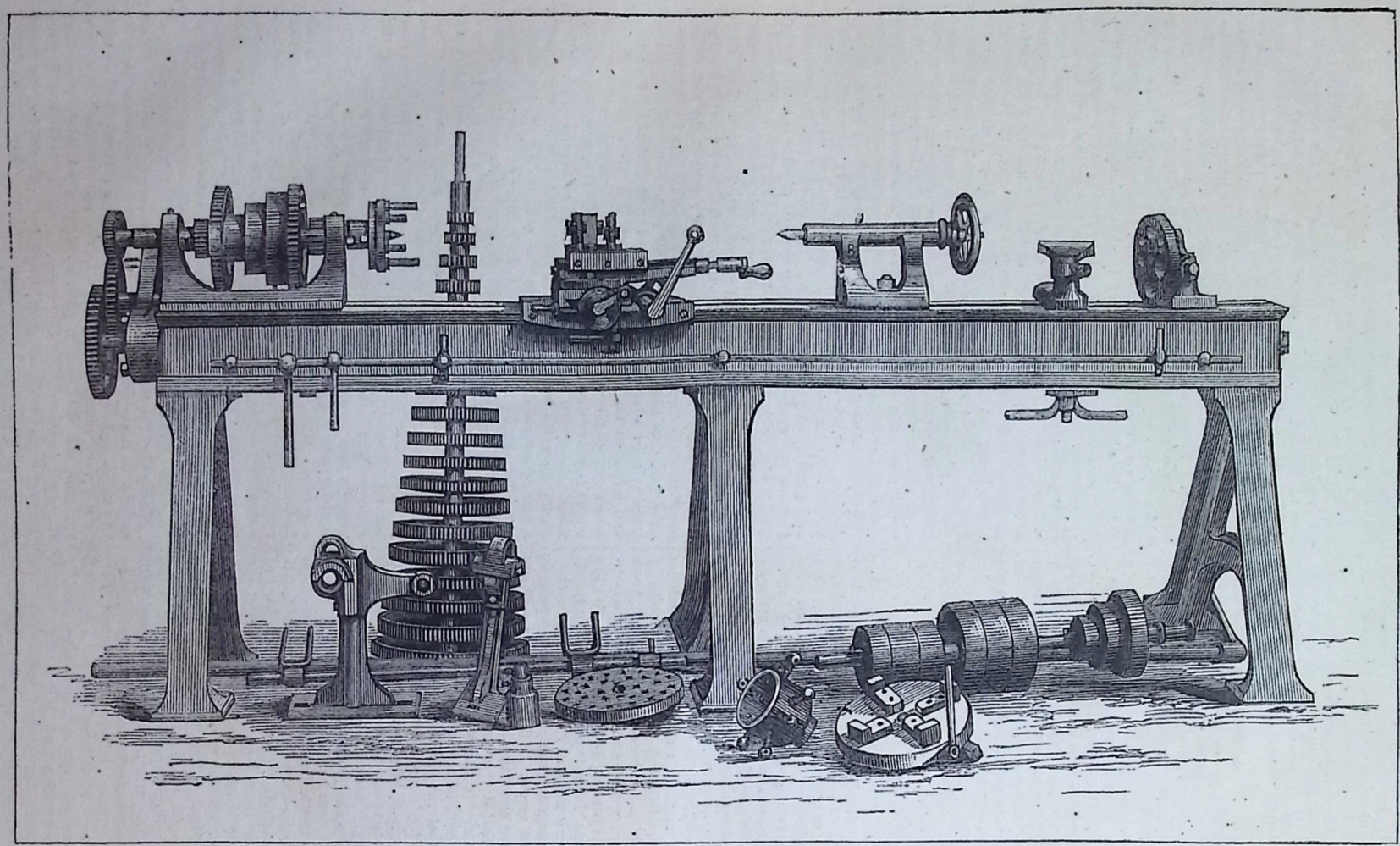


Fig. 102.—LIGHT SCREW-CUTTING LATHE BY MESSRS. WHITWORTH AND CO.

An excellent screw-cutting lathe is made by Messrs. Cunliffe and Croom, of Manchester. This lathe has an outside leading screw, and rather a complicated system of change-wheels, the reversing intermediate wheel being arranged on a swing-plate as just described. The bed is formed with a "break" or gap just under the face-plate. A bridge-piece, however, is furnished to complete the surface of the bed. In lathes the largest article that can be turned is determined by the height of the centres, or distance of the centre of the spindle from the surface of the bed, which is the radius of the largest article the lathe will receive. It is occasionally required, however, to turn or bore articles of larger diameter than it would be convenient to have a special lathe for, and as such articles are mostly short, the adoption of a gap-bed renders the lathe equal to these articles without the necessity of its being too heavy for its ordinary work. When a large wheel, for example, has to be bored or turned, the bridge-piece which is placed across the gap is removed, and the height of the lathe-centres is thereby increased, as the diameter of the largest short article the lathe will receive is then equal to double the distance from the centre of the spindle to the bottom of the gap. Gap-lathes find employment chiefly in small workshops, as they may render large lathes unnecessary; but in establishments where there is enough large and small work to keep large and small lathes fully occupied, gap-beds are not in favour.

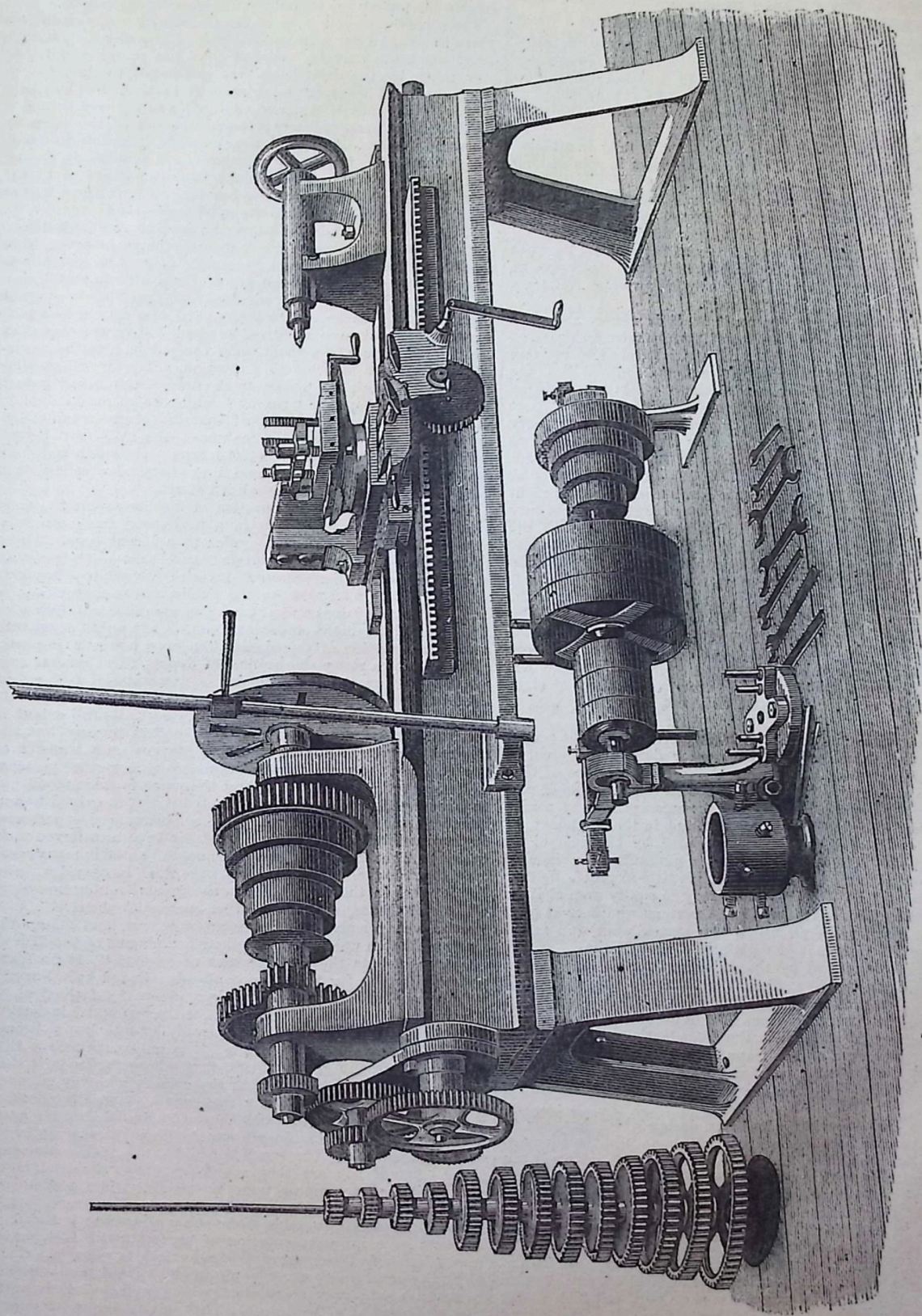


Fig. 103.—SELF-ACTING AND SCREW-CUTTING LATHE BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

TRADE-MARKS.—II.

By A London Barrister.

REMEDIES FOR WRONGFUL USE OR IMITATION.

In our first paper we dealt generally with the nature of trade-marks and the property which can be had in them. A necessary incident of property is that it is liable to invasion; those who have no right to use it are tempted to take the benefit of it in proportion to the undecided nature of it, and the difficulty of repelling or obtaining redress for a trespass. It would be manifest that there must be a preliminary difficulty in all legal proceedings which may be taken with this view in establishing that the particular name or symbol is not *publici juris*. Of course if property in a name or trade-mark be set up it is for the alleged infringers, as in the case of patents, to prove that it is public property. But it is equally clear that any person proposing to institute a suit should know as far as may be what claim he has upon it as an individual, and what right can be set up on the part of the public. The penalty which follows a mistake in this direction is very heavy.

In illustration of these observations, it is merely necessary that we should refer to a case which has very recently occurred in the Court of Chancery. A suit was instituted to restrain the use of the words "Kalydor" and "Odonto;" but the Court held upon the evidence that these words were *publici juris*, and the plaintiff's bill was dismissed with costs. This at once proves how material it is that any person claiming property in words and signs should be reasonably clear in advance that his right to claim a monopoly is well founded. It is not possible always to be sure that a Court either of Equity or Common Law will take the view which appears to be the right one upon the evidence, and upon this very question courts have differed. For example, in the litigation connected with the famous Glenfield Starch, a Vice-Chancellor considered that there could not be any property in the name "Glenfield," and dismissed a bill filed by Mr. Wotherspoon. This decision was reversed on appeal, the Court above being of opinion that the word "Glenfield" as connected with starch had become the exclusive property of one person. Therefore, with all the care in the world defeat may be possible, and should it be made to appear that the name or symbol in which property is claimed has been used to any extent so as to create a mere show of right of property in another than the claimant, the remedy will be entirely gone.

What the remedy is we will now consider. At law the proper remedy is by an action on the case for deceit, and proof of fraud on the part of the defendant is of the essence of that action. But a Court of Equity will act on the principle of protecting property alone, and it is not necessary for the person applying for the injunction to prove fraud in the defendant, or that the credit of the plaintiff is injured by the sale of an inferior article. The injury done to the plaintiff in his trade by loss of custom is sufficient to support his title to relief. Neither will the plaintiff be deprived of remedy in equity even if it be shown by the defendant that all the persons who bought from him goods bearing the plaintiff's trade-mark were well aware that the goods were not the plaintiff's manufacture. If the goods were so supplied by the defendant for the purpose of being sold again in the market, the injury to the plaintiff is sufficient. Again, it is not necessary for relief in equity that proof should be given of persons having been actually deceived, and having bought goods with the defendant's mark under the belief that they were of the manufacture of the plaintiff, provided that the Court be satisfied that the resemblance is such as would be likely to cause the one mark to be mistaken for the other.

Where a tradesman has adopted a design which happens to resemble the trade-mark of another tradesman, and the adoption has been innocent, the Court, while doing all the justice it can to the originator, will do whatever is consistent with that course to preserve to the second adopter the benefit to be derived from the use of a distinctive symbol. It is very easy to sail near the wind in imitating a label or trade-mark, but an imitation which just avoids an injunction is not to be indulged in, for the Court under such circumstances would refuse to give the defendant any costs. In judging of the facts of any case in which an injunction is sought for, the Court will look at the intention to deceive. Where the description of a manufactured article is in substance retained, and the name of the maker is added to, and there is a general and sufficient imitation to deceive the public, the Court will interfere by injunction.

The general principle is, that the Court will always interfere where there has been a fraudulent use of the name. But the Court must not only be satisfied that the course which has been taken by the defendants was calculated to deceive the public, but that it has been represented to them by the plaintiffs as having that effect; and that, after such representation, the defendants persisted in continuing the use of the name in the same manner. Then, on the plaintiffs bringing the case before the Court, the Court considers itself justified in saying that that which was not fraudulent at first became so by the defendants persisting in the same course, and that therefore the plaintiffs would be entitled to the relief they asked.

If a trade-mark be dishonest, no proceeding can be taken to restrain its general use. The dishonesty must, however, have the effect of a fraud. A good example of an innocent misrepresentation is afforded by the use of the word "patent" in a trade-mark. It might be supposed, at first sight, that to use that word in a trade-mark describing any particular article for which a patent had not been obtained, as described in our papers on that subject, would be a fraud upon the public, and the trade-mark therefore disentitled to protection. But Vice-Chancellor James pointed out, in considering the used of the term "patent thread," that the word "patent" might be so used as not to deceive any one, or cause a belief that the goods so called are protected by a patent. He instanced the case of "patent leather boots;" and speaking of the term "patent thread," he said that it had so long been used in the particular trade that it might be said to have become a word of art.

The general law on the question of dishonesty on the part of a person claiming property in a trade-mark has been very clearly discussed by a learned judge in a recent case. There cannot now be any doubt, it was said, that a trader may be guilty of such misrepresentations with respect to his goods as to amount to a fraud upon the public, and to disentitle him on that ground against a rival trader to the relief in a Court of Equity which he might otherwise claim. What would constitute a misrepresentation of this description may, however, in particular cases be a reasonable subject of doubt. The general rule seems to be that the misstatement of any material fact calculated to deceive the public will be sufficient for the purpose. It was urged that if the principle be pressed to its full extent it will prevent the use of the name of a firm by any but the original partners, and will of course prevent on a transfer of the business the right to use the name by any other persons. The answer given to this was, that the name is understood not to be confined to those who first adopted it, but to extend to and include persons who have afterwards been introduced as partners, or persons to whom the original partners have transferred their business. The name of the firm continues to be used in many cases long after all the original traders have died, or ceased to have any interest in the concern, as in the great banking houses of Child and Coutts, and many other mercantile houses. If a manufacturing house use the name of a firm, and stamp the name of its firm upon its goods, though the name of the firm no longer represents the same persons as at first, it is no fraud upon the public for the reasons already alluded to. For the same reason, the use of the whole trade-mark of the firm by the new partners or their successors, if the term "trade-mark" be understood in what has been already said to be its proper sense, is no fraud upon the public; it is only a statement that the goods are the goods of the firm whose trade-mark they bear. But trade-marks, or what are called such, may go much further than this, and contain statements materially affecting the value of the goods to which they are affixed. In such cases they must be judged of like statements made in separate labels or advertisements. The question will be, are such statements true? And if not, are they misstatements of material facts, and calculated to impose upon the public? If a trade-mark represents an article as protected by a patent, when, in fact, it is not so protected, it seems that such a statement *primâ facie* amounts to a misrepresentation of an important fact, which would disentitle the owner of the trade-mark to relief in a Court of Equity against any one who pirated it. What the issues in a case of alleged piracy or imitation will be, well appears from the case of Crawshay *v.* Thompson. That was an action for wrong-

fully, knowingly, and fraudulently stamping bars of iron made by the defendants with a stamp resembling one used by the plaintiff, which the defendants knew and intended to be in imitation of the plaintiff's, and which was used by the defendants in order to denote that their iron was made by the plaintiff; and for knowingly selling the iron so marked as and for the plaintiff's iron. A correspondence between the parties was given in evidence, in which the plaintiff charged the defendants with using the mark as being a fraud upon him. The defendants, in answer, asserted that they had used the mark for many years continuously. This was not so in fact; but it was shown that the mark had been adopted by them in the execution of orders received from foreign correspondents. It was held that it was properly left to the jury to say whether the defendants' mark bore such a close resemblance to the plaintiff's as was calculated to deceive the unwary and injure the sale of the plaintiff's goods; and, secondly, whether the defendants used the mark with the intention of supplanting the plaintiff, or whether it was done in the ordinary course of business in execution of orders. In the same case it was ruled that the notice of the resemblance of the mark, given by the plaintiff to the defendants, did not, in the absence of proof of any intention to imitate it on the part of the defendants, give the plaintiff any cause of action.

Having considered the general position of the immediate parties before a Court of Law or Equity, we will go on to discuss the liabilities of persons having forged trade-marks in their possession, and afterwards we will see what are the criminal liabilities of forgers. In a case decided last year, a Court of Equity said that a person having in his hands or under his control goods bearing a forged trade-mark is bound, upon the facts being brought to his knowledge, at once to submit to do whatever he might be compelled to do upon bill filed; otherwise, however innocently the goods may have come to him, he will be liable for the costs of a suit instituted by the person whose right is infringed for the purpose of obtaining relief. The Court went so far as to say that it did not make any difference whether the goods are sent to a person who does not deal in the article consigned, and whose duty is simply to distribute the goods to other persons, or whether the goods are sent to him as consignee for his own purposes. It will not do for him to say, "I do not know anything about the goods sent. I do not know if they have any, and if any, what brand on them or whose it is." It is his duty to know this; and if he receives notice that they bear a fraudulent imitation of another man's brand, he ought to ascertain this as speedily as possible after such notice, and to take the proper and necessary steps to prevent their being disposed of in that state. It may be that without notice, he does not know that the trade-mark, when he sees it, belongs to another; and if so, he may deal with the goods innocently; but as soon as he is informed of the fact, he should act at once, so as not to be in any event, either from wilful or from accidental ignorance, made a party to a fraud committed by another.

In a case tried at law it was alleged that the plaintiff agreed with the defendant to manufacture for him firebricks, to be marked as he should direct; that he directed that they should be marked with R.'s name, he well knowing that R. manufactured firebricks marked with that name to indicate that they were manufactured by him; that the plaintiff, ignorant of the manufacture of firebricks by R., and that marking firebricks according to the directions of R. would be wrongful, manufactured firebricks for the defendant, and marked them with the name of R.; that R. filed a bill in Chancery for an injunction and account against the plaintiff; and that the plaintiff, in order to compromise the suit, paid R. a sum of money. It was held that this complaint disclosed two grounds of action; first, because the plaintiff was liable to the injunction, although he used the trade-mark of R. innocently; and, secondly, because the natural consequence of the defendant's act was to involve the plaintiff in a Chancery suit, even if he had the means of defending it, by reason of his having used the trade-mark of R. innocently.

Before noticing, in conclusion, the criminal responsibility of those who forge and otherwise act dishonestly by trade-marks, we may notice that by the recent Statute 25 and 26 Vict., c. 88, a limited warranty is declared to be implied upon sale transactions of goods in two cases. First, when any person sells or contracts to sell any chattel or article "with any trade-mark thereon, or upon any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing together with which such chattel or article shall be sold or contracted to be sold," the sale or contract shall be deemed to have been made with a warranty that such trade-mark was genuine and true, and not wrongfully used, unless the contrary be expressed in some writings signed by or on behalf of the vendor, and delivered to and accepted by the vendee. Secondly, when any person sells or contracts to sell any chattel or article, "upon which, or upon any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing together with which such chattel or article shall be sold or contracted to be sold, any description, statement, or other indication of or respecting the number, quantity, measure, or weight of such chattel or article, or of the place or country in which such chattel or article shall have been made, manufactured, or produced," the sale or contract shall be deemed to have been made with a warranty that no such description, statement, or indication was in any material respect false or untrue, unless the contrary be expressed in a writing signed, delivered, and accepted as under the preceding provision. The principal penal provisions of this statute enact that every person who, with intent to defraud or to enable another to defraud any person, shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing in, on, or with which any chattel or article shall be intended to be sold, or shall be sold or uttered or exposed for sale, or intended for any purpose of trade or manufacture, or shall enclose or place any chattel or article, or cause or procure any chattel or article to be enclosed or placed, in, upon, under, or with any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing to which any trade-mark shall have been falsely applied, or to which any forged or counterfeited trade-mark shall have been applied, or shall apply or attach, or cause or procure to be applied or attached, to any chattel or article, any case, cover, reel, ticket, label, or other thing to which any trade-mark shall have been falsely applied, or to which any forged or counterfeited trade-mark shall have been applied, or shall enclose, place, or attach any chattel or article, or cause or procure any chattel or article to be enclosed, placed, or attached, in, upon, under, with or to any cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing having thereon any trade-mark of any other person, shall be guilty of a misdemeanor, and every person so committing a misdemeanor shall also forfeit to Her Majesty every such chattel and article, and also every such cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing as aforesaid in the possession or power of such person; and every other similar cask, bottle, stopper, vessel, case, cover, wrapper, band, reel, ticket, label, or other thing made to be used in like manner as aforesaid, and every instrument in the possession or power of such person, and by means of which any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall have been applied, and also every instrument in the possession or power of such person for applying any such trade-mark or forged or counterfeit trade-mark as aforesaid, shall be forfeited to Her Majesty; and the Court before which any such misdemeanor shall be tried may order such forfeited articles as aforesaid to be destroyed or otherwise disposed of as such Court shall think fit. Further, every person who, with intent to defraud, or to enable another to defraud any person, shall forge or counterfeit, or cause or procure to be forged or counterfeited, any trade-mark, or shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any chattel or article not being the manufacture, workmanship, production, or merchandise of any person denoted or intended to be denoted by such trade-mark, or denoted or intended to be denoted by such forged or counterfeited trade-mark, or not being the manufacture, workmanship, production, or merchandise of any person whose trade-mark shall be so forged or counterfeited, or shall apply or cause or procure to be applied any trade-mark, or any forged or counterfeited trade-mark, to any chattel or article, not being the particular or peculiar description of manufacture, workmanship, production, or merchandise denoted or intended to be denoted by such trade-mark, or by such forged or counterfeited trade-mark, shall be guilty of a misdemeanor, and every person so

committing a misdemeanor shall also forfeit to Her Majesty every chattel and article belonging to such person to which he shall have so unlawfully applied, or caused or procured to be applied, any such trade-mark or forged or counterfeited trade-mark as aforesaid, and every instrument in the possession or power of such person, and by means of which any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall have been so applied, and every instrument in the possession or power of such person for applying any such trade-mark, or forged or counterfeited trade-mark as aforesaid, shall be forfeited to Her Majesty; and the Court before which any such misdemeanor shall be tried, may order such forfeited articles as aforesaid to be destroyed or otherwise disposed of as such Court shall think fit.

In proceedings which may be taken under this Act, it will be sufficient to state the mark to be a "trade-mark" or a "forged or counterfeited trade-mark," without further description or setting forth any copy or fac-simile thereof. By section 11, a conviction is not to affect any right or civil remedy which any party aggrieved by the offence may be entitled to; but compulsory evidence given by the offender is not to be admitted against him. By section 12, an intent to defraud, etc., any particular person need not be alleged in any information, conviction, etc., or proved. By section 15, penalties or sums of money forfeited may be recovered by action of debt in any Court of Record, or instead "by a summary proceeding before two justices of the peace having jurisdiction in the county or place where the party offending shall reside or have any place of business, or in the county or place in which the offence shall have been committed."

The seller of the article bearing a forged trade-mark is by section 6 of this Act bound upon demand in writing delivered to him or left for him at his last-known dwelling-house, or at the place of sale, or exposure for sale, by or on behalf of any person whose trade-mark shall have been forged or counterfeited, or used without lawful authority or excuse, to give to the person requiring the same, or his attorney or agent, within forty-eight hours after such demand, full information in writing of the name and address of the person from whom he shall have purchased or obtained such chattel or article, and of the time when he obtained the same.

This entirely exhausts the law relating to the rights and remedies of persons having trade-marks, and the liabilities of persons who infringe such rights.

TECHNICAL DRAWING.—XCI.

DRAWING FOR METAL-PLATE WORKERS (*continued*).

To describe the form of a "tapering piece" of piping, to join two pieces of piping, which are both vertical, but not in the same axis, and which are of different diameters.

Let A B C D (Fig. 663) be a portion of the one pipe, and E F G H the other.

Join B E and C F, and produce the lines until they meet in O; then if O C be produced until it is equal to O B—viz., to I—and I B be joined, it will be evident that O I B is the elevation of a cone placed obliquely on the lower cylinder, and which is cut off at B C, E F.

Now draw any diameter to the cylinder, as J K, and on it describe a semicircle, representing half of the section of the cylinder.

Divide this semicircle into any number of equal parts—viz., L, M, N, P, Q.

Through these points draw perpendiculars cutting the line B C in *l*, *m*, *n*, *p*, *q*; and from *l*, *m*, *n*, *p*, *q* draw lines to O.

Now from O, with radius O *n* (Fig. 663), describe an arc, N′ N″ (Fig. 664), and on this arc set off the lengths into which the semicircle is divided.

From O draw radii through all these points, producing them beyond the arc N′ N″.

From O as a centre, and with O B, O *l*, O *m*, O *p*, O *q*, and O C as radii, describe arcs cutting the radii in Fig. 664 in *q*′, *p*′, *n*′, *m*′, *l*′, and B′, etc., and the curve being drawn through these points will give the bottom of the tapering piece.

The upper curve is to be drawn in the same manner, and will be understood from the diagram.

ROOFS AND DOMES, AND THE METHOD OF COVERING THEM.

Although the whole subject of the development of prisms has been treated of in "Projection," it is deemed desirable to enlarge on the subject here in order to show the application of these studies to the zinc-worker and plumber.

This branch of the subject is most important to plumbers and zinc-men, and therefore the general method of projecting roofs is repeated from "Drawing for Carpenters and Joiners," so that subsequent lessons may be engrafted on it.

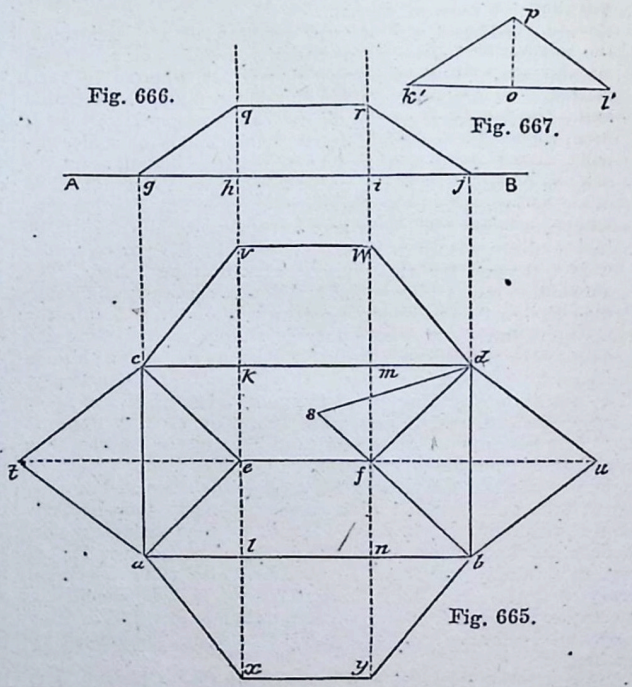
Fig. 665.—In this example *a b c d* is the plan of a building to be covered by a hipped roof.

To draw the plan of the roof.

Bisect the angles of the parallelogram, and the bisectors meeting in *e* and *f* will form the plans of the hip-line, and the line joining *e* and *f* will be the plan of the ridge.

Let it now be required to project the elevation from this plan.

Draw any horizontal, as A B (Fig. 666), and perpendiculars from *c*, *e*, *f*, *d*, cutting A B in *g*, *h*, *i*, *j*, and produce *h* and *i* indefinitely. Produce the perpendicular at *e* until it reaches *l*; then it will be clear that *k l* is the width of the roof-trusses (at *k l* and *m n*), which would be at right angles to *a b* and *c d*.



Draw *k′ l′* (Fig. 667) equal to *k l* in Fig. 665, and at the middle point, *o*, draw the perpendicular *o p* equal to the real height of the truss, which is, of course, a matter dependent on the taste or defined purpose of the architect. This triangle will then be the shape of the truss at this point, and is the section *across* the roof.

Make *h q* and *i r* in Fig. 666 equal to *o p* in Fig. 667. Draw *g q*, *q r*, and *r j*, which will complete the elevation, and this will also be the longitudinal section through the ridge.

We now have to determine the real length of the hip. To do this, draw *f s* (Fig. 665) equal to *o p* (Fig. 667), and at right angles to *f d*.

Join *d s*, then the right-angled triangle *d f s* is the true shape of the hip-truss. This will be understood by cutting a piece of cardboard of the shape described, and placing it on its edge, *d f*. Then it will be seen that *d s* will be the length of the hip.

To develop the covering of this roof—a matter of the greatest importance to the plumber and zinc-worker.

It will be, of course, understood that the surface will consist of four planes, which will meet at the hip-lines.

Now it has already been shown that the ends are triangles, of which *a e c* and *b f d* are the plans; the length of lines *a c* and

b d remains unaltered, but the real length of *c e*, *a e*, *b f*, *d f*, has been proved to be *d s*.

Therefore on *d b* and *a c* construct isosceles triangles, having *d s* for the two remaining sides; these triangles, then, *a t c* and *b n d*, are *the true shape of the coverings of the ends of the roof.*

Now from *c* and *d*, with radius *c t*, describe arcs cutting the perpendiculars *k* and *m* in *v* and *w*. Join *d w*, *v c*, and *w v*. Then the trapezoid *c v w d* is the development of one of the planes forming the side of the roof-covering.

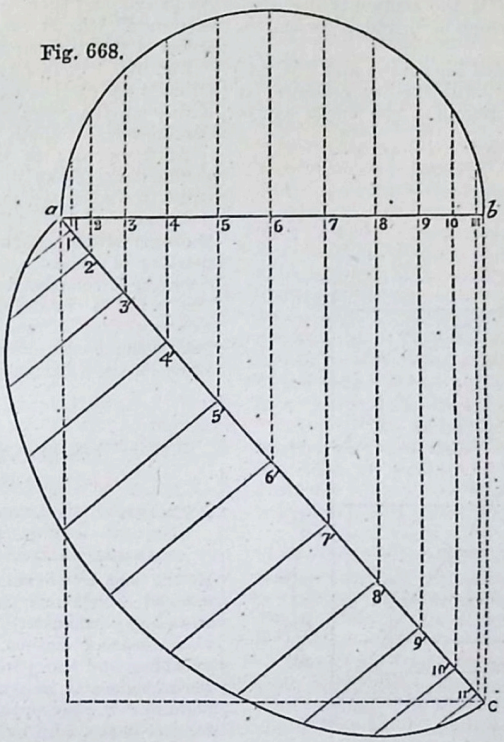
The same length set off on the perpendiculars *l*, *n* will give the points *x*, *y*, which will complete the fourth plane.

We will now proceed to find the form of the hip when the roof is a groined one.

It will be clear that if a spectator stands on the platform of a railway at the side of a semi-circular arch by which a road is carried over it, he will then see that, whilst the face or elevation of the arch, where it crosses the railway at right angles, is semicircular, its span being of course the diameter of the circle, of which it is half; the length from the springing near which he is standing, to the most distant springing (that is, the one on the opposite of the line at the other end of the arch), will be much longer; yet the arch there is not any higher, although its span, thus taken crosswise, is longer, because the diagonal of a square or other rectangle is longer than any one of its sides.

The principle on which to find the curve that would reach to the springing at which the student is standing to the one referred to, is also shown in Fig. 668.

Fig. 668.



On *a b* describe a semicircle, and from the points 1′, 2′, 3′, 4′ erect perpendiculars cutting the semicircle in 1, 2, 3, 4, or mark off *any* divisions in the semicircle, and from them draw perpendiculars to *a b*. Now from the points where the lines 1′, 2′, 3, 4′, etc., cut *a c* draw lines perpendicular to *a c*; make each of these equal in height to those correspondingly lettered in the semicircle, and the curve drawn through their extremities will be the form required.

This study has already been fully worked out at Fig. 86 in "Technical Drawing," to which the student is referred.

It is, however, desirable for the continuity of the present branch of our subject that we should in this place repeat Fig. 86 and its elucidation, desiring as we do that each section of our papers on "Technical Drawing" should as far as possible be complete in itself; and as the business of the zinc-worker and the plumber are so intimately associated with that of the building trades, the lesson herein given forms a necessary step in the present course.

Fig. 669.—Here A B C D is the plan of a building to be covered by a groined roof. The arch, the spring of which is A C and B D, is a semi-cylinder. The arch which has its springing in A B and C D, being of the same height but of wider span, is a semi-cylindroid.

A *cylindroid* is a solid body of the character of a cylinder; but whilst in a cylinder all sections taken at right angles to the axis are circles, in the cylindroid all such sections are ellipses. It is, in fact, a *flattened cylinder*. The curve of the groin then is generated by the penetration of a cylindroid and cylinder.

On A B describe the semicircle which represents the face of the arch at the ends A B and C D, and divide it into any number of equal parts, *a*, *b*, *c*, etc.

It is only necessary to use the *quadrant*, as throughout the working the measurements are the same on each side. Draw the diagonals A D and B C.

From *a*, *b*, *c*, *d*, *e*, *f* draw lines perpendicular to A B cutting the diagonal A D in *a*′, *b*′, *c*′, *d*′, *e*′, *f*′, and set off the same distances on the other half of the diagonal.

From these points draw lines at right angles to A C, and passing through it in points 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11. Mark off on the perpendicular 6 the height 6 *f*, equal to the

Fig. 663.

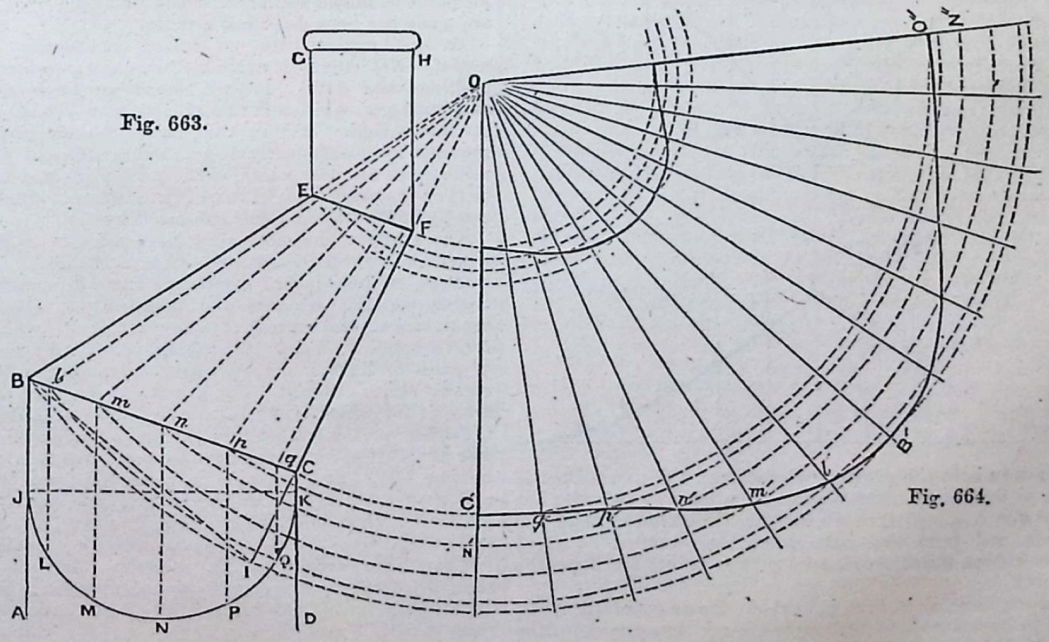


Fig. 664.

height of the semicircle *f*; and on the perpendiculars 5, 4, 3, 2, 1 mark off in succession the heights of the perpendiculars *e*, *d*, *c*, *b*, *a*, as contained between the semicircle and its diameter A B. Set off the same heights on the corresponding perpendiculars on the other side of 6 *f*, and the curve traced through these points will be a semi-ellipse, which is the section of the semi-cylindroid forming the arch, of which A C and B D are the springings.

We now proceed to find the curve of the groin; and it will be evident that although the span is still further increased in length, the heights of the different points in the curve will be

Fig. 669.

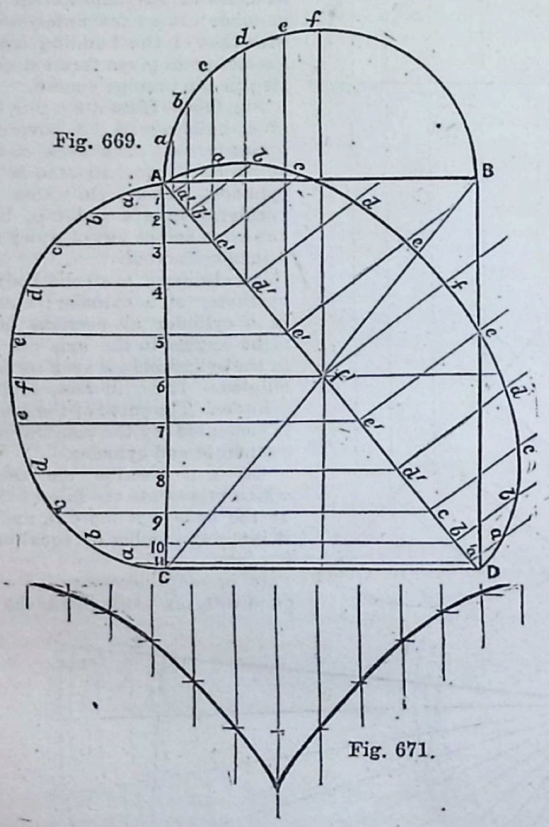
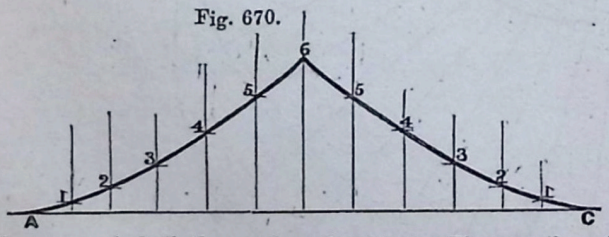


Fig. 671.

Fig. 670.



the same as in both the previous elevations. The span then of the arch at the groin is the diagonal A D (or B C) to which the divisions *a*, *b*, *c*, *d*, *e*, *f* have already been transferred from the semicircle, and from these the lines were carried at right angles to A C, on which the height of the points in the curve were set off.

These points—viz., *a'*, *b'*, *c'*, *d'*, *e'*, *f'*—in the diagonal, then, will be seen to be common to both arches, since they are the plans of the points in the roof where the cylindrical and cylindroidal bodies penetrate each other. At these points, therefore, draw lines perpendicular to the *diagonal*, and mark off on these the heights of the perpendiculars in the semicircle from which the points on which they stand were deduced. These extremities being connected, the curve so traced is the groin curve, and will give the shape for the centering of the groin, as the semicircle and semi-ellipse will for those used in the elevations of the arches.

It now only remains to develop the surfaces of these arches, that is, to find the shape of the zinc or lead which would cover the roof of a railway station, or other building, when formed as here described.

The student is advised to work this study on a large scale on cardboard, and then to cut out the separate parts, which he can afterwards join at their edges, thus constructing an accurate model of the roof required.

Fig. 670.—Draw any straight line, and commencing at A, set off on it the distances into which the curve A C is divided (measuring on the *curve*, not on the springing line)—namely, the distances A, *a b c*, etc.

At the points on the straight line thus marked, draw perpendiculars; make the middle one equal to 6 *f*; those on *e e* equal to 5 *e*; those on *d d* equal to 4 *d*; those on *c c* equal to 3 *c*; those on *b b*, to 2 *b*; and those on *a a* equal to 1 *a*. Join the extremities of these perpendiculars, and the two curves meeting in a point, and joined by the original straight line, will form the development of the covering of the cylindroidal arch.

Fig. 671 is the development of the semi-cylindrical arch. As this is worked in precisely the same manner as the last, but taking the measurements from the semicircle, no further instructions are deemed necessary.

INDIAN RUBBER.—VI.

By George Gladstone, F.C.S.

MECHANICAL APPLICATIONS — MIXTURES — SPONGY CAOUTCHOUC — EBONITE, ITS CHARACTER AND USES — VULCANISED SOLUTIONS—AMERICAN TRADE.

In the last article some of the mechanical applications of vulcanised caoutchouc have been referred to, but the list is far from being exhausted.

Waterproof clothes, including articles made for fishing and yachting, and those who go long voyages at sea, form an important class of manufactures. Amongst these are swimming-belts and life-preservers filled with air, suits for divers, floats for life-boats, and even portable rafts and boats for military purposes or inland explorers. The principle upon which they are made has been described already.

To the surgeon the vulcanised caoutchouc is extremely useful. Not only is it available for making water-beds, elastic cushions, and the like, but the thread can be woven into belts and bandages, which shall be efficient and yet easy to wear at the same time. Besides this, some of their instruments are required to be sufficiently firm and also sufficiently pliable, and made of a material which shall not be affected either by the heat or the exudations of the body, a union of conditions which can be fulfilled by no other substance known.

There is yet one more very large class of applications for which it is specially adapted—the mechanical. Besides the carriage springs before mentioned there are railway buffers, engine packing, washers and pump-valves, wheel tires, hose pipes, and a great variety of other articles to which it is very largely applied. Vulcanised tubing, whether for the conveyance of gases or liquids, possesses great advantages over that made of any other material. For gas it can be used with movable burners for which no metal can be made available; while, on the other hand, a leather tube cannot be made sufficiently tight. For liquids leather piping is often used, but it is very liable to become leaky, and can only be preserved from becoming stiff and then cracking, by unintermitting use, or by being well lubricated when laid aside. This, however, is inconvenient, and often, from carelessness or otherwise, inefficient. The Indian-rubber article, on the contrary, may be left wet in the most careless manner without any damage to its efficiency. Water hose, or any other that has to bear considerable pressure from within, is made of sundry layers of the vulcanised rubber with canvas foundations, a single ply, as it is termed, being able to resist a pressure of about 20 pounds to the square inch; while one of four-ply, such as is used in fire-engines, will stand a pressure of about 175 pounds.

Rollers for letter-press printing may be made of it, the permanent elasticity and durability of the material recommending it for that purpose. To the calico-printer it is of greater advantage, being specially adapted for the manufacture of

printers' blankets, and also of furnishers. The blankets are formed of alternate layers of Indian rubber and cloth; by their use a printer can produce fine and delicate patterns, that could not result from the ordinary woollen blanket. These patent articles are capable of printing 25,000 pieces of cloth, and the power required is much diminished, in consequence of their peculiar elasticity requiring less pressure to produce the pattern. The furnishers are made with a roughened surface, which takes up the colour, and applies it to the engraved roller. The same furnisher can readily be applied to any colour without waste; the composition of the printing pastes and colours have no injurious effect upon them, which will perform their work satisfactorily for a series of years.

Its efficiency in deadening the force of concussions and in preventing jarring or vibration is so great that a long series of patents has been taken out for applying it to machinery in a variety of ways, and it has been very extensively adopted for bearing-springs and buffers on many of our railways. The test already given of its elasticity is sufficient evidence in this respect; but when a solid block is subjected to great pressure from above it tends to bulge out at the sides. An increased power of resistance can therefore be gained by confining the elastic block within metal rings, or by building up the spring or buffer of a number of thin laminæ instead of one piece, and separating the several laminæ by thin discs of metal. In this way the thickness and efficiency of the spring can be increased to any extent without more bulging than there will be in the case of one thin layer only.

Amongst these uses must be mentioned that of elastic tires for wheels; they are particularly convenient for trucking goods in warehouses or railway stations, as well as for bath and invalid chairs, as they deaden the sound at the same time that they prevent jarring, so that the truck or vehicle thus provided will roll along without the slightest noise, and in an extraordinarily soft and easy manner. A carriage or chair will, under such circumstances, last much longer than one which is only furnished with unyielding metal tires, as the fastenings have not the same tendency to work loose. The vulcanised tire is usually protected by having a narrow metal flange on each side, but of less depth than the thickness of the Indian-rubber band —in fact, only just sufficiently deep to keep the latter from slipping off the wheel.

Many of the mechanical applications involve the use of a large bulk of material, while at the same time they may not imperatively require the highest elasticity or other characteristic qualities that can be obtained. To meet such cases, various mixtures have been devised on economical grounds, and the following combinations have been found to answer well, though they are open to modification both in respect to the proportions of the ingredients and the temperature to be employed in vulcanising the compound. Eight parts of caoutchouc, with two of sulphur, and three of Stockholm pitch, or similar quantities of the first two articles combined with one of pitch, will make an article which after vulcanisation will be suitable for railway packing or other rough uses. It should be rolled out into sheets, or made into such other form as may be required, and then submitted for an hour to a temperature of 290° Fahr., pressure being applied during the process to prevent it from blistering or becoming porous. The common resin of commerce may also be used as a substitute for pitch, in which case eight parts of caoutchouc to one of sulphur and three of resin, or to two of sulphur and one of resin, will make suitable combinations.

For some purposes a spongy or cellular substance is found convenient. This character can be produced by mixing with a solution of caoutchouc, or a combination of caoutchouc and gutta-percha, a solution of chloride of sulphur; after a short time the whole becomes coagulated or gelatinised, and it should then be exposed to a temperature of about 212°, by immersing the vessel containing it in boiling water or otherwise, until the solvents are evaporated. Another plan of producing the same effect is to subdivide the Indian rubber into larger or smaller pieces, and to fill with them a vessel of any open or net-like construction of the required form, and then immerse it in the vulcanising solution: when the superfluous solvents have run off, after it is taken out of the bath, the several pieces will be sufficiently united to form an easily compressible and elastic mass suitable for cushion-pads and other purposes.

There are some other modes of making Indian-rubber tubing or hose pipe, which were not described in the previous article, but which ought not to be passed over altogether. It can be made of threads of a size proportioned to that of the hose, braided upon a core formed of rope which has previously been coated with treacle and glue, or glue and whiting, and made perfectly smooth; the braiding may be repeated, or a coating of Indian-rubber solution may be given, and when dry, rolled under pressure with a gentle heat. The hose is finished by immersing it in a vulcanising solution, which will produce the necessary change, and at the same time unite the several layers or coatings; lastly, the core is easily withdrawn by soaking it in boiling water. Another mode is to take worsted yarn of a suitable size, saturate and coat it with a solution of caoutchouc until the animal fibre is thoroughly covered; then braid in on a core as before, roll it under pressure with heat, either with or without a previous wash of Indian-rubber solution, and then immerse it in the vulcanising compound. A third plan of producing the same result is that of winding threads or narrow strips of Indian rubber spirally round the core, keeping the edges quite close, and, if necessary, winding another tape or thread over the first in the contrary direction; after this they should be rolled well under pressure, heated, and then subjected to the action of the vulcanising solution; the core is finally to be withdrawn as before described.

Some of the minor, but not the less important, mechanical applications may be advantageously illustrated by the annexed drawings of washers, which will show how they will make perfectly tight joints, which will not be affected either by the gases or liquids which may be passed through the pipes, or by the metal of which they are made. Fig. 1, in the next page, shows the simplest form of a flange-joint, with the Indian-rubber washer (marked 1*a*) which would be used in such case; Fig. 2, a socket-joint with its appropriate washer, marked 2*a*; and Fig. 3, a bevel-joint with the washer (3*a*) which would fit such an arrangement.

Ebonite or vulcanite are the special names given to that description of vulcanised rubber which is prepared at the highest temperature. It is black and hard like ebony, only very slightly elastic, and takes a good polish; is not affected by water, acids, whether hot or cold, alkalis or grease, or by any ordinary temperature. It can be used for almost all purposes in which horn is available; and more than that, because it can be had in much larger pieces and of any required form. Were it not for its cost it might be substituted for any hard wood, as a piece of ebonite can be wrought with ordinary cabinet-makers' and turners' tools like wood and ivory; or it can be moulded in the same way as the softer article is, the ebonite only requiring exposure to a higher degree of heat before being removed from the mould. Some of the most common things made of this description are combs, penholders, handles for knives, sticks, etc., watch-guards, brooches, bracelets, portable cups, taps, etc.; but there are many others for which it is particularly suitable, such as the splints used by surgeons in setting broken bones, and also for various kinds of apparatus where hardness combined with a slight degree of pliability and a resistance to the heat and secretions of the body of the patient are necessary conditions. The electrician and the experimental chemist also find it to be a very convenient substance of which to make some of their apparatus, on account of its being a non-conductor of electricity, as well as unaffected by most chemical substances.

In some of the processes of manufacture a good deal of waste in the shape of cuttings necessarily occurs, and at first some difficulty was experienced in converting them to a profitable use, as the vulcanised article cannot be wrought up in the masticator, and is less readily acted upon by solvents. They can, however, be dealt with in the following manner:—The scraps should first be passed through a mill to tear them into shreds, or under rollers to reduce them to thin sheets, so as to expose as great a surface as possible to the action of the solvent, and then boiled in oil of turpentine.

As a considerable temperature is necessary in this case, several of the ordinary solvents cannot be used with safety for this purpose, and turpentine is the only commercial article that can be conveniently employed. If the caoutchouc has not been strongly vulcanised, a temperature of 250° will be sufficient; but what has been originally converted at a greater heat will

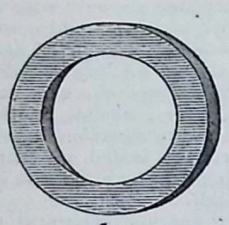
require also a hotter solution, sometimes up to 312°, to dissolve it. Hard or horny caoutchouc, such as will come under the designation of ebonite, is, however, so intractable as not to be worth operating upon at all. The most convenient plan is not to keep up the boiling until the whole of the material is dissolved up, but to put in an excess of the latter, and when enough has been dissolved to make a solution of sufficient strength for the purpose intended, to pour that off, and then re-fill the vessel with fresh turpentine.

The vulcanised solutions are employed for coating cloths and other materials for rendering them air or water proof; for coating various articles to protect them from decay in consequence of wet; for the manufacture of cements and varnishes by mixing them with oils, pitch, resin, asphalte, etc., and generally for purposes where the high quality of the product is not of so much importance. When dry the solution possesses more or less the peculiar properties of the vulcanised rubber; but the process is of principal value, in an economical point of view, in using up what would otherwise be waste material.

It has been already mentioned that the manufacturers of caoutchouc in the United States of America claimed the honour of having first discovered the process of vulcanisation. Goodyear's Indian-rubber works in that country were maintained on a large scale prior to that period, and it is indubitable that what led to the experiments which resulted in the employment of heated sulphur for this purpose, was the possession of some small scraps by Mr. Brockedon which had all the properties of the vulcanised article, and which had been furnished by a party from the other side of the Atlantic, who would not divulge the mode of its preparation.

The American manufacturers have, from the first, shown a great appreciation of the valuable properties of Indian rubber, and a most praiseworthy energy in applying it practically to every imaginable purpose. Those who had the privilege of visiting the Great International Exhibition of 1851 cannot fail to remember the very remarkable collection of objects of every description, manufactured from this article, in the space allotted to the United States, and which, indeed, formed the most notable feature amongst all the contributions from that country.

Those manufactories have generally been supplied with the raw material from Parà in Brazil, so that during the twenty years extending from 1836 to 1856, the United States imported from thence 3,886,534 pairs of native shoes, 15,951,491 lbs. of fine and mixed caoutchouc, 2,818,788 lbs. of coarse and inferior qualities; while the direct exports to England from the same port during those years only amounted to 117,135 pairs of native shoes, 7,784,262 lbs. of fine and mixed caoutchouc, 3,870,464 lbs. of coarse and inferior qualities; in addition to which, however, there were also shipped, *viâ* Cowes or Falmouth, and the European market, 22,640 pairs of native shoes, 32,824 lbs. of fine and mixed caoutchouc, some portion of which was doubtless ultimately landed in this country.



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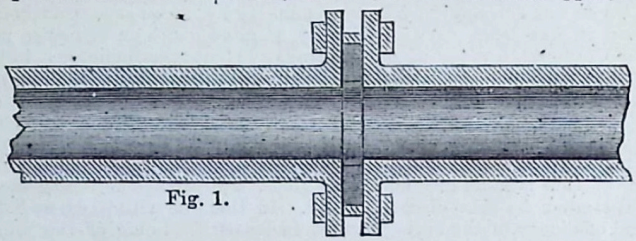
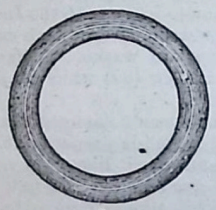


Fig. 1.



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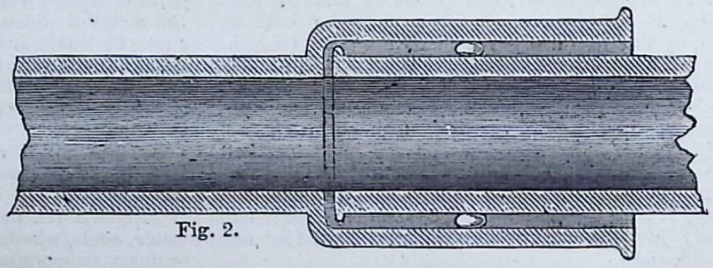
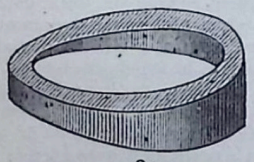


Fig. 2.



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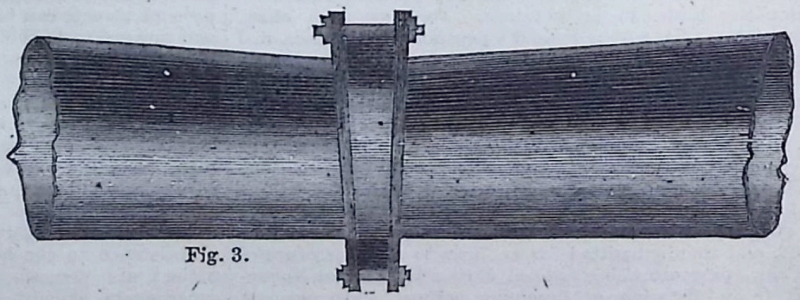


Fig. 3.

The East Indian caoutchouc, on the contrary, has been principally consumed by the English manufacturers; for while the exports from Singapore to Great Britain during the six years ending with 1855 were 1,547,616 lbs., only 524,832 lbs. were shipped to America.

The goloshes so largely used as overshoes in wet weather are principally manufactured in the United States, but most of the other Indian-rubber articles which are consumed in this country are made here.

There are some considerable works for the manufacture of Indian-rubber goods in Paris, which date back to the year 1828; but both the machinery required for the purpose and the men employed in the works had to be sent originally from London; and for some time after the works had been established in France the solution of caoutchouc used in waterproofing the French goods was supplied from this country.

GUTTA-PERCHA.—II.

By George Gladstone, F.C.S.

PURIFICATION—COMPOUNDS—MOULDING—TUBE-MAKING—STRENGTH OF PIPING—COATING OF TELEGRAPH WIRES—MANUFACTURE OF SHEET, BANDS AND CORDS—VULCANISING—SUBSTITUTES FOR GUTTA-PERCHA.

The first thing to be done in dealing with this article is to purify it from all the adulterations, accidental or otherwise, which may contaminate it. These are not a few, for a pound of the best gutta-percha as imported will often contain one ounce of impurities, and inferior qualities may not unlikely be found to include 25 per cent. of foreign matter: even sand and stones are not unfrequently incorporated with it by the unscrupulous collectors, much to the disadvantage of the buyer, not only because he may thus pay for much useless weight, but also on account of the damage which such substances cause to his machinery.

The usual plan of purifying it is as follows:—The lumps of gutta-percha are placed upon a sloping table, at the lower edge of which is a revolving disc, in which there are generally three slots radiating from the centre, which carry a similar number of knife-edges set in the same way as in a carpenter's plane. The disc is commonly driven by steam-power at a considerable speed, reducing the lumps of gutta-percha to thin shavings, which pass through and fall down in a heap on the other side of the disc. The slope upon which the feeding-table is made, forces the lowest lumps of gutta-percha down upon the disc so that they are caught by the knife-edges, and the process thus goes forward with rapidity, unless stones or other hard substances are met with, which seriously injure the blades.

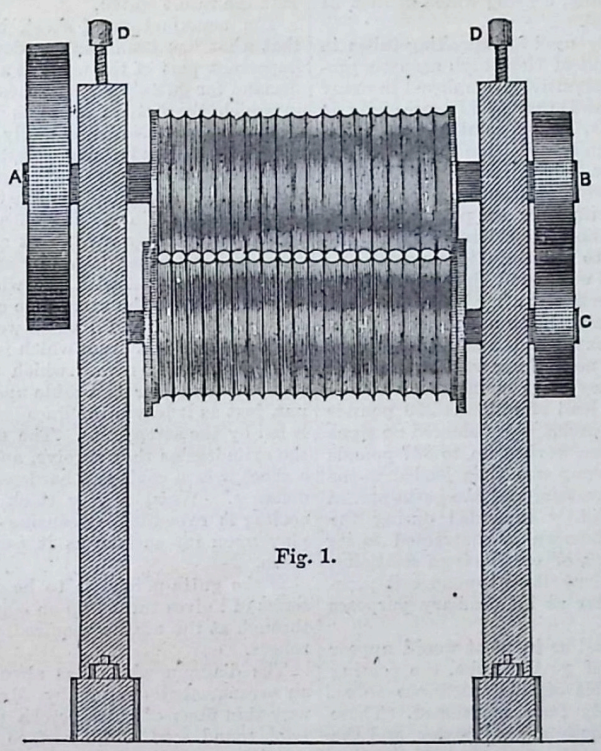


Fig. 1.

The shavings which are thus made are then conveyed to a tank full of boiling water; the waste steam from the engine employed for driving the slicing machine and other apparatus to be presently described, will suffice to keep the water up to the required temperature; and in these tanks the gutta-percha is stirred about until the impurities exposed by the cutting have been washed out of it. The gutta-percha being rather lighter than the water, floats on the surface, while the dirt sinks to the bottom. The warmth of the water has at the same time reduced the gutta-percha to a soft condition, and while in this state it is transferred to the teaser—a drum containing a rotating cylinder armed with teeth, similar in principle to the masticator of Indian rubber originally invented by Mr. Hancock—which tears it into shreds. The teaser is generally driven at the rate of about 800 revolutions per minute. From the teaser it falls into a tank below, where the rest of the impurities are separated, these settling to the bottom, whilst the gutta-percha, which is now sufficiently pure for most purposes, floats on the surface of the water.

To bring these shreds into a mass again, they are thrown into another bath of boiling water, which reduces them to a soft plastic state; and from this they are passed into the kneading machines (again similar in construction to those employed in the caoutchouc works), the projecting cogs in the cylinder of which press the still plastic gutta-percha against the sides of the drum until all the water and air-bubbles are expelled, and the contents are reduced to a thoroughly homogeneous mass.

An improved form of kneader is made by fixing two parallel rollers with screw surfaces so as to work nearly up to one another, and then passing the gutta-percha between them: in the threads of the screws diagonal notches are cut, by which the efficacy of their action is increased.

The experience gained already in the treatment of caoutchouc led the parties interested in that manufacture to secure by patent right, as rapidly as possible, the application of gutta-percha to almost all the purposes for which the former article was adopted, and with only just such modifications in the processes as the different nature of the article dictated. It will be unnecessary to go through these in detail, as they have been already described under the head of "Indian rubber." It will suffice to say that it is likewise treated with sulphur or sulphurous compounds, which, according to the temperature employed, will render it more tenacious and pliant, or on the other hand much harder, and always less susceptible to the influence of heat. It is compounded with ochre, silicate of magnesia, lime, asphalte, pitch, and all kinds of conceivable substances, either for the purpose of producing a softer surface, or to impart to it certain colours, or to make a varnish, or—which must undoubtedly be the sole object of many of the patents which have been taken out—to furnish a cheap substitute for the pure article without any regard to quality.

There are, however, certain operations which can be conducted upon principles which would not answer in the case of Indian rubber, and for which gutta-percha is in all respects the more suitable material. The simplest of these applications is perhaps that of forming mouldings or other impressed figures. By reducing it to a plastic state, for which purpose it is only necessary to warm it thoroughly—which can be most conveniently done by immersing it in boiling water—it can be easily stamped out with a die into a scroll or beading or other simple form, or can be moulded by hand into a much more elaborate device. For these purposes the material will remain sufficiently plastic so long as it retains a temperature of 130° to 140°, and such ornamentations can be bent or otherwise adapted to, and also nailed to the framework for which they are intended, without fear of breaking, or even of any change in form after having cooled down to 110°.

Articles of more complicated form can, however, be produced by forcing it into moulds, such as would be used in metal-work. For this purpose the moulds must be made of metal in segments, and the several pieces firmly bolted together; there must be a good-sized aperture at one end for the admission of the gutta-percha, and smaller ones for the escape of the air wherever the particular form of the object to be made may render such necessary. The large aperture is fitted to the nozzle of a cylinder which is filled with the plastic gutta, and then the piston worked by a screw or other power forces the contents through the nozzle into the mould. As soon as threads of the gutta are seen to issue from each of the small air-holes, further pressure is discontinued, the mould unscrewed, and the object cut off and trimmed. In order to prevent the material from becoming chilled, which would render it too refractory, the apparatus should be inclosed in a steam-jacket, the temperature of which can be regulated with precision, and maintained at such a point as will make the gutta unite in the mould into a uniform solid mass.

Very similar to this in principle is the manufacture of gutta-percha tubing, which is carried on upon a very extensive scale, as this is one of its most valuable applications. The purified

material is transferred from the kneaders into the cylinder, which communicates with a mould formed of an iron tube open at the further extremity, and containing in the centre a solid circular core; tubes and cores of various sizes are kept so that they can be changed when required according to the size of piping to be made. Pressure being applied by means of a piston, as in the former case, the gutta-percha in the cylinder is forced through th tubular die, and issues from the open end in the form of a hollow pipe without any seam or joining of any kind; but at the temperature required to keep the material soft the piping cannot be handled without destroying its circular form, and it would even collapse if left to itself; it is therefore made to dip under cold water as it comes forth from the mould, and this both expedites the cooling and keeps the tube distended until it is sufficiently firm to retain its proper shape. The water-trough should be about 50 feet long, and by the time it has traversed that length it will be in a fit condition to be wound off upon a drum. By a special arrangement for keeping the cylinder constantly supplied with material, the piping can be made of any length without joining, a thing which cannot be done with any other known material.

Thin pipes thus made are largely used for speaking-tubes in houses and public offices, on account of their high acoustic properties; and piping of all sizes is extensively employed in many manufactories for conveying water and other liquids, especially as it is altogether unaffected by acids, saline solutions, and fermented liquors, so that it is equally available in breweries, chemical works, and all others in which large quantities of liquids have frequently to be transferred from one receiver to another. In water-works more particularly its power of resisting internal pressure is an important consideration. Experiments have therefore been made to ascertain this point; and at the Birmingham water-works it was found that tubes of the diameter of $\frac{3}{4}$-inch and $\frac{1}{8}$-inch respectively, after being attached to the main and subjected for two months to a pressure of 200 feet head of water, had not deteriorated in the slightest degree. Having determined this point, the next thing was to test their strength, and with this object they were connected with the hydraulic proving pump, the usual load of which is 250 pounds to the square inch. As the gutta-percha pipes showed no signs of strain at this pressure, it was then worked up to 337 pounds without affecting the pipes. The pump was then loaded to the greatest pressure the valve would sustain, and the gutta-percha still remained perfect; it had slightly expanded during the trial, but on the force being withdrawn it contracted to its original dimensions—a beautiful test of its thorough elasticity, though requiring such a force to show it as to render it practically devoid of that quality so far as all ordinary purposes are concerned.

The making of tubes naturally lead us to what would appear to be a very different application of gutta-percha, the coating of telegraphic cables. The qualities of this substance as an insulator of electricity have already been mentioned. These combined with its resistance to the action of salt water, and the ease of manipulation, have resulted in its very general adoption for the coating of the copper wires used in submarine telegraphic communication. We have now only to deal with the last point. In "The Electric Telegraph" (Vol. I., page 181) is a diagram drawn of the actual size (Fig. 11), representing a cross-section of the Atlantic telegraph cables which were completed in 1866. Of these the first broke in mid-Atlantic in the course of laying down in 1865, and was recovered next year, when both it and the new cable were successfully laid. Both cables have remained efficient ever since. It will be seen that the part shaded dark, which immediately surrounds the seven central wires, consists of four rings: these represent so many layers of gutta-percha, each separated by a thin film of varnish known as Chatterton's compound. It is with the four rings of gutta-percha that we have now chiefly to do. They are made upon the same plan as the hollow tubing, except that the core of the mould, instead of being a fixed piece of metal, consisted of the actual copper wire to be coated, and which was drawn forward through the mould at a rate proportional to that at which the gutta-percha was forced in by the piston. The first layer having thus been deposited, a thin coating of Chatterton's compound, of which gutta-percha is the principal ingredient, is spread over it; and when dry this is ready to enter a second mould of about one-tenth of an inch greater internal diameter than the preceding, in passing through which it acquires a second layer, and so on until four perfect coatings of the insulator are deposited around the central wire, each separated by a film of varnish. The exterior portions of the cable shown in the diagram are merely added for the sake of strength, and to protect the insulating material from internal injury. In preparing the gutta-percha for this purpose unusual precautions are taken to ensure its purity; the crude article is rasped down very fine before being washed, and after being worked in both hot and cold water, it is placed in cylinders having bottoms of fine wire gauze, through which it is forced by a hydraulic machine at the temperature of 212° Fahrenheit, preparatory to its being sent to the kneaders. Some of the earlier submarine cables, insulated with gutta-percha, have been taken up, and on examining them no sensible deterioration in the quality of the article has been perceptible in those parts which have been completely and continuously submerged. The Irish cable from Holyhead was thus examined after seven years' use, and that which stretched from Orford Ness to Scheveningen after five years' submergence, with the result stated.

The manufacture of sheet, bands, and cord is more simple that what has been already described; but these form a very important part of the work at any factory, as there is a great demand for gutta-percha in these forms. The rolling machine, in which the first of these is produced, consists of a pair of steel cylinders fixed horizontally one above the other in a frame furnished with adjusting screws, by which the space between the cylinders can be varied according to the thickness of sheet required. The principle is illustrated by Fig. 1 in the preceding page, only that in making sheet the surfaces of the cylinders are smooth. They revolve at an equal speed in opposite directions, the one being driven by an endless band from the engine which is connected with the wheel A, whilst the motion given to the first is at the same time communicated to the second by the cog-wheels B and C which work into one another. At some little distance is a drum which is driven by the same power, and carries an endless web which passes over the cylinders. In front of the latter is a table upon which the plastic material is put, just as it leaves the kneaders, and from which the machine is fed by the attendants. The gutta-percha is carried between the cylinders as they revolve, and these roll the lumps out into a sheet, which cools and hardens as it passes to the drum in the distance. When a very thick sheet is being rolled out, the cooling is expedited by causing an artificial current of air to play upon its surface as it passes from the cylinders to the drum.

If the gutta-percha is to be converted into narrow bands, a series of knives turned up on edge are so arranged as to cut it through at the widths required, just as it passes out from the rollers.

The diagram which has already been referred to illustrates an arrangement devised by Mr. Hancock, either for cutting very thin films of gutta-percha into narrow slips, or of making solid round cord. The surface of the two cylinders shown is cut into semi-circular grooves, and so arranged that when brought together by the adjusting screws D, D, the grooves shall exactly correspond and form true circles. A thin film passed between these as they revolve will be cut into narrow slips, but a sheet at least as thick as the extreme diameter of the spaces will, by the same apparatus, be converted into round cord. The substitution of one flat surface will evidently produce a semi-circular cord, and by varying one or both of them any simple form can be given to the gutta-percha at pleasure. The thin films are cut when cold, but in making cord the material must be warmed sufficiently to render it plastic, say to about 200° Fahrenheit.

The mode of vulcanising gutta-percha is similar to that adopted with Indian rubber, but the effect of the process is less marked. If 2 per cent. of chloride of sulphur be used, the resulting article will be capable of extension when heated to 100° or 120°, and if allowed to cool when thus stretched it will continue extended until re-heated, when it will resume its original dimensions. An increase in the quantity of sulphur combined with it is attended by greater resistance to the influence of heat: 10 per cent. of chloride of sulphur renders it unaffected by boiling water, and 15 per cent. produces a hard and horny substance.

The value of gutta-percha being considerable—the best com-

mercial article being usually worth 3s. per pound wholesale—any other substance which will really serve as a substitute is worth attention. The juice of the Balatta tree is capable of replacing the lower qualities, and it can be procured in considerable quantities from British Guiana. The tree abounds there in the forests, and it will allow of being tapped every two months. Another tree which yields a similar article grows abundantly along the whole line of the Western Ghauts in Travancore, at an elevation of 2,500 to 3,000 feet above the sea-level.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLIV.—DR. JAMES BRADLEY, F.R.S.

ONE of England's most celebrated astronomers, James Bradley, was born at Sherborne, a village in Gloucestershire, situated six miles north-west of Burford, and five miles eastward of North Leach, in the year 1692—the stirring epoch of La Hogue, of Steenkirk, and the massacre of Glencoe.

In due time he went to Oxford, and was admitted a commoner of Baliol College on the 15th of March, 1710, and took the degree of Bachelor on the 14th of October, 1714, and that of Master of Arts on the 21st of January, 1716. As his friends destined him for the Church of England, his studies were regulated and arranged with that view; and as soon as he was of the proper age to receive holy orders, the Bishop of Hereford, Benjamin Hoadley (who had been translated from Bangor, and was afterwards Bishop of Salisbury), who had conceived a great esteem for him, gave him the living of Bridestowe, near Oakhampton, in Devonshire; but soon after he was inducted to that of Llandewy Welfrey, in the county of Pembroke.

Though he continued to fulfil the duties of his sacred profession, he also devoted some time to astronomy, and made such observations as led to those discoveries which distinguished him as one of the greatest astronomers of the Georgian era—observations which won him the notice and the friendship of Sir Isaac Newton, Dr. Halley, and many other members of the Royal Society of London, into which he was soon elected as a member. Among his friends and patrons was the then Lord Chancellor, Thomas Parker, who was created Viscount and Earl of Macclesfield in 1721.

Soon after, the chair of Savilian professor of astronomy at Oxford became vacant by the death of the celebrated John Keil, and on the 31st of October, 1721, James Bradley, then in his twenty-ninth year, was appointed to succeed him. On receiving this more congenial appointment, Mr. Bradley resigned his church livings, and applied himself wholly to the study of his favourite science.

He discovered, in course of his observations, which were almost innumerable, the settled laws of the alterations of the fixed stars, from the progressive motion of light, combined with the earth's annual motion about the sun, and the nutation of the earth's axis, arising from the unequal attraction of the sun and moon on the different parts of the earth.

Of these effects, the former is called the *aberration* of the fixed stars, the theory of which he published in 1727, and the latter the *nutation* of the earth's axis, the theory of which he produced ten years subsequently, so that in this space of time he communicated to the world two of the grandest discoveries in modern astronomy, and these must for ever make a memorable epoch in the history of that science.

As lecturer in astronomy and experimental philosophy at Oxford, he succeeded Mr. Whiteside in 1730. This office proved one of considerable emolument to him, and he held it till within a year or two of his death, when ill health compelled him to resign it. The esteem and friendship of his colleague Halley he always preserved, and the latter being quite worn out by age and its consequent infirmities, thought that he could do no better service for the science of astronomy than to procure for James Bradley the office of Regius Professor of Astronomy at Greenwich, an appointment which he had himself held for many years with honour and reputation. With this kind view, he wrote many letters, requesting his friend's permission to apply for a grant of the reversion of it, and even offered to resign in his favour; but ere this could be adjusted, Dr. Halley died, and Dr. Bradley obtained the place in February, 1741, through the interest of another friend—the Earl of Macclesfield—who was afterwards President of the Royal Society; and it was upon receiving this appointment that the University of Oxford conferred upon him the diploma of Doctor of Divinity.

On a rising ground in the park of Greenwich, commanding one of the richest and most varied prospects that can well be conceived, stands the Royal Observatory, which must for ever be associated with the names most celebrated in astronomy. It contains excellent apartments for the Astronomer Royal, and the finest instruments that art can provide. It was founded by Charles II. in 1675, and in the following year Flamstead began that famous series of observations which has been continued by his successors to the present day.

"Among the astronomers which the Royal Society has produced," says La Place, "I shall cite Flamstead, one of the greatest observers that has ever appeared; Halley, rendered illustrious by his travels, undertaken for the advantage of science; by his beautiful investigation concerning comets, which enabled him to discover the nature of the comet of 1759; and by the ingenious idea of employing the transit of Venus over the sun to determine its parallax. I shall mention *lastly Bradley*, the model for observers, and who will be for ever celebrated for two of the most beautiful discoveries ever made in astronomy—the aberration of the fixed stars and the nutation of the axis of the earth."

To Bradley succeeded Nathaniel Bliss, M.A., in 1762.

As Astronomer Royal the former was in his proper element, and with unwearying diligence pursued his observations; but however numerous the collection of astronomical instruments at Greenwich, it was impossible for an observer such as Dr. Bradley not to desire to increase them, as well to answer his own particular views as in general to make observations with greater exactness.

He took the opportunity, therefore, in 1748, during a visit of the Royal Society, made annually to examine the instruments and receive his observations for the year, to urge so strongly the necessity of repairing the old instruments and providing new, that an application was made to George II., who was pleased to order £1,000 for the purpose. Bradley was overjoyed on receiving this sum, which he disbursed, with the assistance of the eminent Mr. Graham and Mr. Bird, and thus succeeded in furnishing Greenwich Observatory with as complete a collection of astronomical instruments as the most skilful enthusiast could desire.

The living of the church at Greenwich having become vacant during Dr. Bradley's residence at the Observatory, it was offered to him; and upon his declining to accept it, from the conscientious scruple "that the duty of a pastor was incompatible with his other duties and necessary engagements," George II. granted him a pension of £250 over and above the astronomer's original salary from the Board of Ordnance, "in consideration," as the Royal warrant of 1752 expresses it, "of his great skill and knowledge in the several branches of astronomy and other parts of mathematics which have proved so useful to the trade and navigation of this kingdom."

In 1748 he became entitled to the benefaction of £30 yearly willed to the lecture-reader and experimental philosopher at Oxford by Nathaniel Crewe, originally Dean of Chichester, and Bishop of Oxford in 1671; and honours came upon him from other quarters. Thus in 1747 he was elected a member of the Academy of Sciences at Berlin; in 1748 of that of Paris; in 1754 of that of St. Petersburg; and in 1757 of that of Bologna.

Dr. Bradley was remarkable for his placid, gentle, and modest character. Though he was a fluent speaker, and possessed the happy art of expressing his ideas with clearness and precision, yet no man was a greater lover of silence, for he seldom spoke, save when he deemed it absolutely necessary to do so. Nor was he more inclined to write than to speak, for he published very little, and he had a strange diffidence which made him afraid that his works might fail to please, and hence injure the reputation he had already won. Yet many of his papers were printed in the *Philosophical Transactions of the Royal Society*. His private character was in every respect estimable, and his modesty prevented him from soliciting that attention and patronage which were necessary to ensure the publication and success of great and even small works in those days, and which

reduced authorship to a system of degrading adulation and toadyism.

As a man of science and observation, the public character of Dr. Bradley is fully established by his works. His observations made at the Royal Observatory, Greenwich, during a period of twenty years, were collected in thirteen large volumes, and in the year 1776 were transferred to the University of Oxford, on condition that they should be printed and published by that learned body.

By too close application to study, Dr. Bradley, for nearly two years before his death, became afflicted by serious depression of spirits, and this interrupted the course of his useful labours. This distress, the result of over brain-work, took the form of apprehension that he should outlive his rational faculties; but the terrible evil that he so much dreaded never came upon him. In June, 1762, he was seized with inflammation in the kidneys, and this ailment terminated his existence on the 13th of the following July.

His death happened at Chalfont, in Gloucestershire, when he had attained his seventieth year; and he was interred at Minching Hampton, in the same county.

In June, 1791, the Board of Longitude, seeing no prospect of the publication of those MSS. committed twenty-five years before to the care of the University of Oxford, passed some resolutions respecting the right of the public to possess these "observations," which being therefore transmitted to the Vice-Chancellor, the Board was, in consequence, informed that the delegates of the press in the University were at last proceeding with the work. In 1798 the first volume was published in a very splendid form, under the title of "Astronomical Observations at Greenwich from the year 1750 to the year 1762."

In 1818 there also appeared in folio, edited by F. W. Bessel, "Fundamenta Astronomiæ pro anno 1755, deducta ex observationibus viri incomparabilis James Bradley."

OPTICAL INSTRUMENTS.—XXIV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MAGIC LANTERN (*continued*).

THE late Andrew Ross was the first to describe a practical arrangement of a triple condenser, which he made in 1836 for Dr. Leeson, at that time Lecturer on Chemistry at St. Thomas's Hospital, from whom he received a *carte-blanche* to construct the most perfect demonstrating lantern his optical knowledge would dictate and his skill accomplish. This condenser is represented at R (Fig. 116): it consists of two plano-convex lenses, and one double-convex lens. The principle of introducing a third lens, for the purpose of dividing the total refraction, in

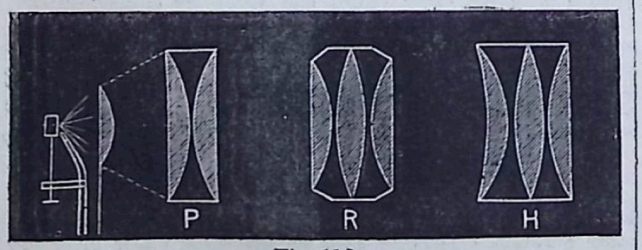


Fig. 116.

a combination of short focus, is correct in practice, as may readily be found by experiment, and is of special value in improving the performance of old-fashioned instruments. Thus P (Fig. 116) shows how the large condensers in the lanterns at the Polytechnic Institution have been made to give more light, by the introduction of a small plano-convex lens between the lime-ball and back lens of the pair of large plano-convex lenses, which necessitate the light being brought in closer to the condensers, a hint probably gained from the arrangement of Mr. Warner, the optician, who effected several improvements in lantern construction, which, however, failed to meet with due appreciation. In the Christmas season of 1864-5 I introduced the form of triple condenser shown at H (Fig. 116), which gives a bright flat disc on the screen, but this is a costly method of attaining the desired end, and I afterwards found I could accomplish it by using short-focussed plano-convex lenses, arranged as at E (Fig. 113, page 257), made of a very bright white flint glass (refractive index about 1·6, crown-glass being 1·5), to compensate for the extra thickness of the lenses employed—one of many optical methods of "robbing Peter to pay Paul," not unfrequently followed in practical optics. I still think the triple arrangement advantageous in its application to weak lights, such as the Argand burner, where every additional increment of light is of the greatest value to the exhibitor, a point not felt to the same extent when we are dealing with intense illuminators.

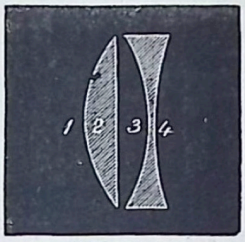


Fig. 117.

In 1861 I had occasion to communicate with Sir John Herschel on the combination F (Fig. 113), referred to by Sir David Brewster in his work on optics, in connection with spectroscopic investigations, which led to the revision of the original formulæ. This was conveyed to me in a letter which, with Sir John's permission, I (as one of the editors at that date) published *in extenso*, with diagrams, in the *British Journal of Photography*. The following extract is of importance in connection with the subject of condensers:—"I regret to say that I fear I have unintentionally misled Sir David Brewster in reference to the radii of the surfaces of a double crown lens corrected for spherical aberration. Your note having recalled the subject to my notice, I have been again looking over the subject, and I have detected an error in one of the *numerical* coefficients of the formula I worked on (see *Phil. Trans.*, 1821), where in section 10 of my paper on object-glasses the value of β instead of $+\frac{32}{27}$ there set down should be $+\frac{14}{27}$, which vitiates the subsequent conclusions so far as a combination of two lenses of *crown glass* is concerned, and renders the radii above given inapplicable. *In point of fact, the spherical aberration of a convex lens requires for its exact correction a lens of a concave character, of inferior power*; and I only wonder that the lens I had constructed for a burning glass on those radii worked so well as it actually does. Had it been otherwise, I should have been led by its bad performance to re-examine carefully all the steps of the calculation, and the error must have been detected. I have still the lens by me, and it gives a clean and perfectly defined focal image of the sun, with a remarkable freedom from loose light when thrown upon a white screen."

"The following combinations, in which the spherical aberration for glass of refractive density 1·500 is corrected, are computed with the *correct* value of β. They all suppose a compound focal length = 2, and a convex resulting character of the combination."

Fig. 117 is a single example out of the six combinations Sir John Herschel gave as types of his corrected formulæ:—

	Surface.	*Curvature.*	*Radius.*	*Focal Length.*
PLANO-CONVEX ...	1	2·0000	0·5000	+ 1·0000
	2	0·0000	∞	
DOUBLE CONCAVE	3	— 0·7932	— 1·2607	— 0·5000
	4	+ 0·2068	+ 4·8356	

Mr. Robert H. Bow, C.E., of Edinburgh, who has paid considerable attention to the important question of the best form of condenser for lantern purposes, in commenting on the above paper in the same periodical, says: "In the six aplanatic combinations given by Sir John Herschel, the convex lens is assumed to be either equi-convex or plano-convex, and of double the power of the concave lens, and both lenses are of the same material. But, of course, other forms of the convex lens could be adopted, and other proportions between the powers of the lenses introduced in carrying out the application of the peculiar leading principle employed in bringing about the correction of the spherical aberration, which is the transmission of the rays through the concave lens in a less symmetrical manner than through the convex one. But when a powerful combination with a large aperture is required to be nearly freed from aberration, as in the condensers of lanterns and solar microscopes, *the introduction of a concave lens is very objectionable, as reducing the grasp and increasing the cost.*"

Mr. Bow considers that the original formula of Sir John

Herschel is preferable. "The leading principle in this other method of correction consists in sending the marginal rays, which suffer over-refraction at a first convex lens, through a second convex lens so formed that these rays will pass disproportionately near to its axis. At the second lens, therefore, the marginal rays will undergo a reduced deviation compared with what attends the more central rays. Fig. 113, G, shows such a combination, which was found to give a focus remarkably free from scattered light when tested as a burning glass, with the parallel rays from the sun entering at the convex face. The first or larger lens is a crossed one, having a focal length $f=10$, while the second lens is a meniscus, with $f = 17{\cdot}83$.* We shall endeavour to explain more particularly the principle of the correction by means of the exaggerated diagram (Fig. 118).

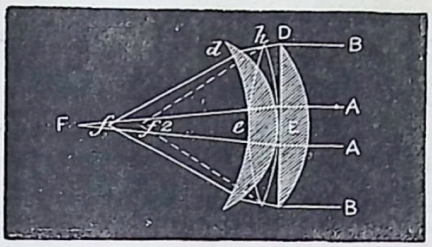


Fig. 118.

"Let d e be the meniscus used, and let the dotted lines h e represent an equivalent bi-convex second lens. Now, the different effects of the two lenses d and h are at once apparent. For each of these the passage of the nearly central ray A E e may be considered the same, and therefore the geometrical focus F as common to both arrangements; but for the marginal ray B D the effects are very different. In the case of the meniscus the place of passage d lies so low that the equivalent refracting angle is reduced, compared with the angle of the dotted lens at h. The deviation at h would therefore be on this account greater than at d, and the difference is still farther increased by the passage of the ray through the double convex at h being more oblique than the passage of the same ray through the meniscus at d. Then, apart from the refraction at h being greater than at d, it will be seen that the fact of d being farther removed than h from D has a reducing effect upon the aberration F f.

"The principles involved in the correction for spherical aberration may therefore be stated as follow:—

"(1.) The distribution of the total refraction between several lenses.

"(2.) The passage of the rays symmetrically, or approximately so.

"(3.) The bending away of the lenses from one another towards the margins.

"These principles are bound up very much one in the other, but the combination shown by Fig. 119, also due to Sir John Herschel, exhibits in a very marked manner the importance of the third principle; for in this combination the first lens is placed in the worst possible position with respect to the second principle, which is therefore sacrificed in order to bring the third into powerful play, *the final result being good.*"†

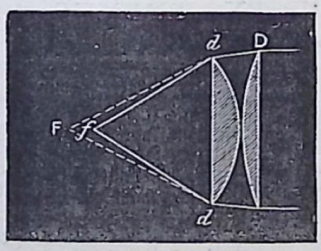


Fig. 119.

"With a large cone of light we cannot get a perfectly aplanatic lens; for, if the extreme and central rays be made to cross the axis at the same point, some of the intermediate rays will be thrown out. We must, therefore, be content with some amount of aberration, and it is best that this should be positive; that is, that there should be a slight excess of refraction of the marginal rays. There is, indeed, a certain advantage attending a moderate amount of aberration, since, were the condenser absolutely free from such, the centre of the disc of light would be more highly illuminated than the margins, but a moderate action of the aberration will have a tendency to equalise the distribution."

Mr. Bow gives the following combinations as examples of efficient condensers, which afford useful data:—

(1.) *Herschel's Original* (Fig. 113, G) radii = (counting from the source of light) – 6·29, 3·69, 35, and 5·83; focal length = 6·41. This he regards as the most perfect, but on account of its concave surface, the most costly in proportion to its power.

(2.) *Herschel's Double Plano-convex* (Fig. 119), radii = ∞, 4·35, 10, and ∞, which gives an even disc of light on the screen, and is inexpensive to make.

(3.) *Crossed Lens corrected with a Convexo-plane Lens*, radii = ∞, 6, 42, and 7. This works well with cheap forms of lenses.

(4.) *Double Convex corrected with a Convexo-plane*, radii = ∞, 7½, 10, and 10.

(5.) *Single Crossed Lens*, radii = 21 and 3½.

TABLE OF COMBINATIONS.

No. of lens combination	1	2	3	4	5
Diameter of first lens	5·16	5·52	5·56	5·34	6
Diameter of second lens	6	6	6	6	0
Combined thickness	1·47	1·45	1·49	1·43	1·93
f for first lens	17·83	8·7	12·0	15	6
f for second lens	10·00	20·0	12·0	10	0
f for combination	6·41	6·06	6·0	6	6
Longitudinal aberration	0·44	0·76	0·63	1·33	2·26
Lateral aberration	0·25	0·45	0·36	0·85	2·27
Angle of cone d F d′	55°	54°	53½°	51°	60°
Angle of cone d f d′	59½	61½	60	64½	92°
Deviation of extreme ray = F d f	2¼°	3¾°	3¼°	6¾°	16°

Mr. Bow considers that such combinations are only to be employed for bringing divergent rays parallel, and that to complete the condensation according to this view, a third lens should be placed in front, as at Fig. 116, to suit the distance of the other focus; but if that focus is a long one, a double combination could, by altering the position of the source of light, be made to converge the rays with but slight change in the aberration calculated. This opinion brings us to consider a condenser constructed for Professor Henry Morton, of the United States, on a different plan to any hitherto described. In this arrangement he employs three lenses as *a collector*, with a small lime-ball placed at *the exact point* of the principal focus, for the purpose of bringing the divergent rays from the source of light into a parallel beam, and gaining the largest angle of incident light attainable, and then converging the parallel rays towards the axis (when required) by means of a double-convex lens, which he regards as "the condenser" proper. In all the arrangements previously described the source of light has to be withdrawn from the exact point of the principal focus of any combination to render the rays convergent, and produce a conjugate focus, thus reducing the value of the angle of the rays incident on the condenser, according to the principle illustrated by Fig. 114, page 258. The form of his "condensing lens" is varied with the nature of the accessory apparatus to be employed, and can be changed without disturbing the light or apparatus. This is arranged to be movable within certain limits, but not so as to allow the rays to come to a focus on a microscopic object, Nichol prism, objective, etc., and cause injury or destruction to valuable appliances by the concentrated heat of the source of light. The collectors embrace an angle of light of 80°, the diameter of the back lens being 4½ inches and 2¾ inches focus. This is a plano-convex, with a radius of curvature of 4½ inches. The two other lenses are 5 inches diameter. The middle lens is a meniscus with radii of curvature (counting from the light) of 30 inches and 6 inches. The radii of curvature of the third lens are 52 inches and 8¾ inches for the back and front faces respectively. The condenser is a double convex of 15 inches focal length. As by moving the source of light we have a simple and ready means of producing

* Gravett's condenser was of this type (Fig. 113, G), and his curves were, for glass of refractive index 1·5 = 6·56 in., 2·39 in. – 26·25, 4·38; focal length of each lens = 7·5; combined focus = 3·75. For glass of refractive index 1·6 = 5·25 in., 2·33 – 63·0 in., 4·50; focal length of each lens = 7·0 combined focus = 3·5. The diameter of the back lens = 4·1 in., that of the front lens = 5 in.

† Mr. Sutton, the late editor of *Photographic Notes*, an accomplished mathematician and optician, says—"The symmetry of two equal plano-convex lenses having their convex sides in contact, is such as to give theoretically the most perfect sharpness of the image; the source of light and the enlarging lens being placed at equal distance from such a condenser."

parallel, converging, or diverging rays at will, I question whether, when using a powerful illuminator, such an arrangement as Professor Morton describes is of real advantage to the physical demonstrator, though the application of the principle to weak lights is quite worth consideration, to gain the greatest attainable angle of rays any "collector" will subtend, and then converge the parallel beam (for showing pictures) by a "condenser" of such form as will correct the spherical aberration.

Mr. Grubb has constructed an achromatic condenser for a gas microscope, the collector of which "receives and transmits an angle of light of 90°;" but no authentic description of this has, I believe, as yet been published.

A concave surface next the light is preferable to a plane one, as there is little or no reflection from the former, so all or the bulk of the incident rays pass through the condenser. As a rule, it should be observed that if the distance between the light and the condenser be less than the distance between the power and the condenser, the flattest side of the combination that forms the condenser should be turned towards the source of light, or that side which depicts on paper held in its focus the sharpest image of a distant object. When, however, the source of light is of considerable size, as in the case of an Argand flame, this rule is of less consequence than when we are dealing with a point of light of great intensity. The quality of the glass of which a condenser is made is of less consequence when the source of light is of some size, for then wavy lines, spiral striæ, specks, air-bubbles, and even irregularities in the curvature of the lenses, are scarcely appreciable; but if the lime-light or electric light is to be employed, the greatest care must be taken in the selection of the glass, and the surfaces must be guarded from injury, for any contained air-bubbles, spots, or deep scratches, especially if in the lens next the stage, would put in an appearance on the screen in a manner not to be desired. Wavy lines and striæ, though objectionable, are comparatively of minor consideration, as such defects do not make themselves so palpably felt during an exhibition. It may here be noted that while striæ and wavy lines in the object-glass or power must be regarded as grave defects, air-bubbles, spots or scratches are (unless numerous) of comparatively small importance, as they merely cause an inappreciable diminution of the light. In some instances the surfaces of the condenser lenses present a greyish tint, arising from imperfect polishing. This is a grave defect, and an unpardonable one, as it results from the negligence of the workman, and stands on a footing with defective curvature, both of which defects can only be attributable to defective supervision on the part of the optician. It is usual to find the ordinary run of double condensers made out of crown and flint glass, which has led to the erroneous supposition that such combinations are "achromatic condensers." As the aim of condenser construction is to pick up the greatest amount of light practically attainable, I think it is better to dispense with green-tinted crown glass, and make both lenses of the most pellucid white flint glass attainable, which, from its greater refractive power, also allows of the lenses being thinner.

As most opticians occasionally meet with over-fastidious customers, I think it right to state that one must not expect to find such perfection in a magic-lantern condenser as characterises an achromatic photographic lens or microscopic object-glass; and as long as any slight defect does not interfere with the proper performance of the combination, it would be unreasonable to expect that which could only be attainable at a considerable increase of cost, without any adequate practical advantage.

A condenser may be considered to perform well when it is of as short a focus as 2½ inches, or even less, and *when properly centered and focussed with the light*, will distribute the collected rays over the disc on the screen, without one part being more brightly illumined than another. If the margin of the disc is brighter than the other parts of the field, then the curves of the lenses are too great in relation to their diameter. A large condenser is not of necessity a good one, since a 3½ or 4-inch combination will show a better enlargement of a hemi-stereograph than one of 6 inches diameter.

The ordinary run of the better class of condensers is 3½ inches in diameter, but I consider *the standard size* should be 4 inches in diameter, as the half of a transparent stereograph, now so often used as a magic-lantern slide, measures 3½ across the diagonal, and the diameter of a condenser should always be half an inch more than the greatest diameter of any slide used.

As all condenser lenses are thick, it is very necessary before commencing an entertainment to warm them through gradually, especially the one next to the light, or the exhibitor may be placed *hors de combat* by the cracking of the lens, as soon as the lime-ball gets thoroughly incandescent, especially if the weather be cold, and for a certainty if a draught of cold air should strike upon the back lens at the moment of opening the door of the lantern; so that an eye ought to be kept upon the direction of open doors and windows, and the lantern be duly shielded. The lenses may be best warmed by placing them in a tray on wash-leather, or a cloth, before a fire, or in an oven, otherwise they must be gradually warmed by slowly raising the heat of the lime-cylinder, and bringing it nearer and nearer to the lens. This also dissipates moisture, which would otherwise dim the lenses for a time. After an exhibition, care should be taken that the lenses are not too suddenly cooled. The lenses should not fit tight into the brass mounting tube, or they would crack on expanding with the heat.

The Concave Condenser.—When the lantern is required for the gas microscope, and it is desirable that the rays from a lime-ball or the electric should be brought to an exact conjugate focal point, I believe it would be better to employ a very perfectly made concave reflector of silver deposited on glass, as shown in Fig. 120, in which case, if a lime-ball is used as the source of light, it should be made as small as possible. Andrew Ross employed this method, and Chadburn has found it the best arrangement for his opaque microscope.

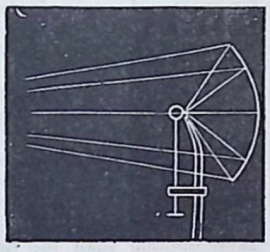


Fig. 120.

The celebrated Euler proposed to substitute for the lens of the lantern a concave mirror, perforated in the middle like that of a Gregorian telescope: this was to be placed in the interior of the lantern with its polished surface towards the light and its convexity towards the object. The light was to be so disposed that none of it should pass directly through the aperture in front of the lantern so as to fall on the screen; and that which was reflected from the concave mirror, after falling upon one with a plane surface, was from thence to be reflected in a contrary direction upon the object. The rays in the pencils proceeding from the object were to pass through a lens in the tube, as in the former construction; and by converging with greater accuracy to points on the screen, they would have produced a more correct image than that which results from refracted light alone.

SEATS OF INDUSTRY.—XXXVIII.

MELBOURNE.

BY WILLIAM WATT WEBSTER.

Only seventy years have elapsed since the discovery of that portion of Australia called Victoria, and only thirty-eight years since the first permanent settlement of colonists was established on any part of it. As early as 1802 a faint effort was made to plant a town on the spot where Melbourne now stands, but it was soon abandoned. A colony, consisting of 1,030 individuals, of whom upwards of 700 were convicts, was founded at Sydney in 1788, and made rapid progress. Offshoots from this settlement began the colonisation of Tasmania, till lately known as Van Diemen's Land, and the earliest permanent settlers in Victoria came from the latter colony. In 1834 a small company from Tasmania, under the leadership of Mr. Thomas Henty, located themselves at Portland Bay, 234 miles from Melbourne. At that date there was not a house nor a garden on any portion of the ground on which Melbourne and its suburbs are built; but in the following year two parties from Tasmania landed at Port Phillip and took possession of the place. The first to arrive was John Batman and his family, and before many months passed he was joined, much to his chagrin, by John Pascoe Fawkner and another company of Tasmanians. Quarrels immediately broke out between the two pioneers, which had the effect of attracting other colonists to the district, and by 1836 a village of rude huts was built, which

contained a population of 224 souls. Fawkner's party raised wheat on five acres of the site of Melbourne. The first land sales took place in 1837, and in the same year the young town was named after Lord Melbourne, then British Prime Minister. In rapidity of growth Melbourne rivals all the towns of America, not even excepting San Francisco. By 1841 it contained 11,738 inhabitants, and in the following year it was incorporated as a town. The population nearly trebled itself within the succeeding five years, it having numbered 32,875 in 1846. In 1847 Melbourne was made the seat of a bishop, and in 1851, on Victoria being formed into a separate colony, Melbourne was fixed upon as the capital, at which date, including its suburbs, the city contained 77,345 inhabitants.

Up till the year 1851 the progress of Melbourne, however extraordinary, was quite normal in its causes. Within sixteen years from the landing of John Batman and his family on the banks of the Yarra-Yarra, a town had grown up that surpassed Sydney in population and extent; that had handsome streets, great warehouses, and busy shops; and that carried on a thriving trade with the sheep-farmers of the interior, and with the mother country, to which it exported large quantities of wool, and from which it imported English produce and manufactures for the use of the colonists. All these remarkable changes had been accomplished gradually though rapidly, and without the aid of any unusual occurrence contributing to its advancement.

But an event now took place that gave an instantaneous impetus, and has exercised a great and permanent influence on the fortunes both of the colony and of its capital city. In February, 1851, gold was found at Bathurst, near Sydney, and in September of the same year rich gold-fields were opened at Ballarat, within 100 miles of Melbourne. No sooner did the news that gold mines had been discovered in Australia reach Europe than adventurers from all countries and of every class flocked to Melbourne, and the stream of emigration flowed on with increasing volume for several years. During one week in 1851 about 10,000 persons landed in Melbourne. The total imports of Victoria for that year only amounted to £1,056,437, but by 1856-57 they rose, under the influence of the gold fever, to £15,182,530. In 1851 the total population of Victoria only numbered 90,000, but in consequence of the rush to the gold-fields it had increased by 1854 to 232,000, and in September, 1867, it amounted to 653,744, of whom 369,103 were males, and 284,641 females. Melbourne contained 77,345 inhabitants at the end of the year 1851, and nearly 90,000 in 1856. By 1861 the population of the city had risen to 125,000, and by 1865, inclusive of the suburbs, to 140,000. From an analysis of the census for the latter year we learn the following particulars:—The city of Melbourne proper then contained 23,700 inhabitants; East Melbourne, 2,000; North Melbourne and Carleton, 16,400; Fitzroy, 11,800; East Collingwood, 12,600; Richmond, 11,000; Jika Jika, 8,200; South Yarra and Prahrm, 13,000; Emerald Hill and Sandridge, 12,400; St. Kilda and Brighton, 11,300; Doutta Galla and Keilor, 3,000; Boroondara and Heidelberg, 5,700; and Cat-Paw-Paw, 6,000. In 1867 the total population of the city and suburbs amounted to 163,308, of which Melbourne proper reckoned 48,500.

The produce of the gold-fields of Victoria in 1852 exceeded a total of 4,247,000 ozs., and they have never since yielded so large a quantity of the precious metal. In 1856-57 a great commercial crisis, which resulted in all but universal bankruptcy, occurred in the city, in consequence of the excessive importations coinciding with a diminished supply of gold, and Melbourne has since undergone many similar, though less general trade vicissitudes. The best result of the gold discoveries was the rapid colonisation of the country, and the consequent development of its agricultural wealth. Perhaps no more graphic and trustworthy account of the changes produced in Melbourne through the influence of the gold discoveries is to be found than in the following remarks from the pen of Mr. Thierry, an old Australian judge. "A more striking contrast," he says, "could not well be furnished than the appearance Melbourne presented when I was there in 1845, and afterwards when I visited it in 1856. In 1845 Bourke Street contained but a few scattered cottages, and sheep were grazed in the thick grass then growing in the street. It was only known to be a street in that year by a sign indicating 'This is Bourke Street.' In 1856 it was as crowded with buildings, and as thronged and alive with the hurrying to and fro of busy people, as Cheapside at the present day. Two branches of Sydney banks supplied the district in 1845 with banking accommodation that only occupied them with business a few hours each day; in 1856 eight banks could scarcely meet the pecuniary exigencies of the community. In the principal street—Collins Street—there was, in 1845, but one jeweller, who displayed a scanty supply of second-hand watches and pinchbeck brooches, in a shop similar to those in which pawnbrokers display their articles of used-up jewellery in the bye-streets off the Strand. In 1856 might be seen in the same street jewellers' shops as numerous and brilliant as those that glitter in Regent Street. The harbour of Hobson's Bay on the morning on which I left it in 1846 contained two large ships, three brigs, and a few small colonial craft. In 1856 the same harbour was filled with about two hundred large London and Liverpool ships, and countless other vessels from America, New Zealand, and other parts. In 1845 there was little more than one clergyman of each religious denomination. In 1856 a numerous clergy of the various denominations officiated; the two principal, Church of England and Roman Catholic, presided over by bishops of their respective creeds. In short, in size, in wealth, in numbers, in varied social enjoyments, the humble town I had quitted in 1846 had been transformed in 1856 into a splendid city, and presented such a transition from poverty to splendour as no city of the ancient or modern world had heretofore exhibited in a corresponding period."

But even this striking contrast does not fully bring out the progress that Melbourne had made by 1856. In the preceding year the Parliament Houses of Victoria, which were estimated to cost £400,000 and are still unfinished, were commenced, and a University with an annual endowment of £9,000, and which now possesses valuable scholarships and exhibitions, was opened. The University possesses a large building, surrounded by extensive grounds, and in 1861 no less than 105 students attended its classes in law, civil engineering, and the arts. In 1859 the Post-office, a magnificent edifice in the Italian style, was completed and opened. Melbourne is well supplied with water, conveyed from a distance of eighteen miles by means of the Yarra-Yarra water-works, and distributed to all parts of the city. Four lines of railway converge at Melbourne. Nearly the whole export and import trade of Victoria is carried on from Port Phillip, an inlet of the Pacific Ocean, which is about forty miles broad from south to north, and at its greatest extent, from east to west, is about forty miles long. This fine basin is only two miles wide at the entrance, which is formed by two projecting promontories called the heads, and is calculated to cover an area of about 800 square miles. In 1861, 3,598 vessels of an aggregate burden of 1,090,002 tons entered and cleared the ports of Victoria, and of these no fewer than 3,023 vessels, representing 995,082 tons burden, entered and cleared the port of Melbourne. The total value of the imports, including bullion and specie, in 1864 amounted to £14,974,815; in 1865 to £13,257,537; and in 1866 to £14,771,711. Among the miscellaneous articles imported the principal consisted of grain of all kinds, flour, drapery, clothing, boots and shoes, hardware and ironmongery, sugar, spirits, tobacco, tea, wine, and opium. The total exports for 1864 reached a value of £13,898,384; for 1865 of £13,150,748; and for 1866 of £12,889,546, including for each of these years respectively gold bullion to the value of £6,206,237, £6,190,317, and £5,900,987. Besides the bullion gold specie was exported from Melbourne to the value, in 1864, of £1,627,872; in 1865 of £809,269; and in 1866 of £961,493. Next to gold the most important article of export is wool. In 1851 the quantity of wool shipped at Melbourne was 16,345,468 lbs. In 1864 the exports of this product were valued at £3,250,128; in 1865 at £3,315,109; and in 1866 at £3,196,471, the latter amount representing 42,390,978 lbs. Of hides, which form a large item in the exports, £94,551 worth were shipped in 1864, and the exports of cattle and sheep in the same year reached a total value of upwards of £170,000. Within the past few years an important trade has been carried on from this port in preserved meats, which seems likely to attain great dimensions. Numerous large companies are engaged in cooking and tinning beef and mutton, both in Victoria and in the other Australian colonies, and this branch of industry is capable of being extended to a much greater degree than it has yet been. The commerce of Melbourne has been almost stationary for some years.

Melbourne is chiefly built on the north bank of the Yarra-Yarra, at a point about nine miles by water and two miles by land from its confluence with the bay of Port Phillip. Vessels drawing twenty-four feet of water can come up to the mouth of the Yarra-Yarra, but owing to bars and shallows the river is not generally navigable by ships of more than sixty tons burden. Williamstown, the port of Melbourne, is situated near the mouth of the Yarra-Yarra. The site of Melbourne is so low that it is liable to be flooded by the river, which occasionally overflows its banks in the wet season, and during heavy rains the streets are sometimes impassable to foot passengers. Throughout the greater part of the year the gutters are filled with water. The houses are mostly built of brick and stone, and the streets are wide and regularly laid out, Collins Street being one-third wider than the celebrated Broadway of New York. Melbourne contains many handsome buildings, and is adorned by a large number of noble institutions. The Free Library is a magnificent room 230 feet in length, 50 feet in width, and 34 feet high, the sides of which consist of numerous small rooms, in each of which are placed books relating to one or two subjects. In 1867, 92,457 visits were paid to this library, which contains 53,000 volumes. Adjoining the library is a valuable exhibition of native and foreign art, and near to it an hospital which expends about £18,000 annually and can accommodate upwards of 400 patients. In the Royal Park there is a small Zoological and Acclimatisation Garden, from which many animals—deer, hares, partridges, pheasants, etc.—have been turned loose in the country, and have thriven and multiplied.

PRACTICAL APPLICATION OF THE FINE ARTS.—XV.

By P. H. Delamotte, Professor of Drawing, King's College, London.

THE ART OF BOOKBINDING (*continued*).

STUDY OF GOOD EXAMPLES—COLOUR—LINE—INDIA-RUBBER BINDING.

Our readers by this time will have seen the various processes required in binding a book, whether permanently, to be placed upon the library shelves, or in the temporary cloth cover with which English books, at all events, are protected during the time that they are handed about from man to man, either over the counter of the circulating library, or amongst personal friends. We have described also the materials employed, and we now come to that part of the subject with which it is peculiarly the province of these papers to deal—viz., the application of the general principles of taste, and of the canons of art to the especial materials we have in hand.

Study of Good Examples.—As in almost all art, a study of the works of ancient masters of the craft, and a comparison with what is now put forward, are most useful, and, in fact, almost absolutely necessary. In following out this course of study, for which we have given some considerable amount of material in the illustrations of this and former papers, to which illustrations we shall allude more particularly and individually hereafter, we cannot but be struck, in this as in many other of the so-called art manufactures, with the increased facility for forming beautiful objects, owing to the introduction of new processes, new and improved materials, and a generally increased knowledge of the modes and appliances of art-manufacture amongst the workmen. At the same time no less strikingly marked is the decreased beauty of the work produced. The workman of old, with his coarser materials, his inability to overcome certain difficulties, and his less extensive knowledge, managed to succeed where the modern workman with all these advantages fails. This is due to many causes, and we will endeavour to point out these in the hope that when they are clearly seen they may be to some extent, at all events, guarded against.

One of the causes of excellence among the ancients arises from this very difficulty of execution of which we have been speaking. When a man has the energy and the determination to overcome great, and it would seem to others, overwhelming difficulties, the same energy and determination are increased by the very process, and, moreover, he comes to regard the impossible as a non-existing bugbear. He has found that what many have reported of as scarcely to be accomplished at any rate he has entered upon with comparative ease, and completed only at the expense of energetic exertion carried a little way beyond what is agreeable and gratifying. Such a man is not content with anything short of success, and when he perceived a design did not fulfil the condition that his taste and feeling required, he was never content till he found out the cause of the failure, and had remedied the evil. The work, therefore, of these men came up to their knowledge and taste for the beautiful. Of course the ancients, like the moderns, made many failures; these failures have perished, as they deserved to perish, and as their modern representatives will disappear, after they have accomplished the purpose of their existence by putting money into the pockets of their authors, and by ministering to and increasing the bad taste of the many who, with abundant means to procure the beautiful, have not only no knowledge of wherein the beautiful consists, but imagine it to reside in some unknown qualities which it is not granted to the ordinary mind of man to possess. In these matters, as in those of higher import, the one thing needful is faith; "unless a man believe faithfully" that there is such a thing as a law which governs all matters of taste, and that such a law "is not far from every one of us," but that it resides in us, and is really part of that valuable but rare inheritance to which we all have a claim, but do not all take up our claim—common sense—and, moreover, that this common sense can be enlarged in its sphere and increased in its power by observation and cultivation, there is no hope that he will ever attain to the true standard of really good taste. Occasionally men who have this faith arise, and they work out their own art to a perfection which is astounding to their contemporaries and the marvel of future ages. Of course such men are rare. Many who start on such a good course faint from the want of some one little ingredient required for great success; but their works remain, and the thing of beauty which they produce is a joy for ever to future generations. What we have said here of bookbinding is true not only of bookbinding, but also of all the manufactures to which fine art can be applied, not only of those discussed in these papers, but also all works to which any, the slightest canon of art can be applied. People are astonished at the success of what are called self-made men; the difficulties of their career lay in the first steps they took; afterwards success followed without difficulty. Every child who learns to walk has overcome a greater and more gigantic difficulty than he will ever after have to surpass in order to become the fastest and most perfect walker of his day. Every boy who plods through the crabbed characters and unintelligible and unintelligent orthography of his native tongue has mastered a greater trial than he can ever after have in acquiring the characters and language of an Oriental tongue. So he, too, who has made the first step in producing a fairly elegant and pleasing cover for a small book has overcome the greatest difficulty he will ever have in his advance towards becoming a man of real taste, and a producer of the most thoroughly good work in his own trade; only let him go on and prosper in spite of opposition of false taste and of weariness.

Colour.—In bookbinding, as in all other arts in which colours are in any way employed, the theory of colour must be studied. The laws of this theory are simple, their application universal; but the acquirement of them demands vast experience and careful training. Of course there are some people who are colour-blind; it is doubtful whether even these could not be exercised by constant practice until the faculty of distinguishing some tints, which seems to lie dormant, might not become developed. But the majority who think that they see, but who really are quite unconscious of what Nature places before them, may, without great difficulty, acquire the general principles upon which the laws of colour depend. The laws of contrast, of complementary colours, of the balancing of tints, are in themselves simple; we have constant applications of them in the natural scenes which lie around us, both on a large scale and on a small, in the bird's wing, the petal of a flower, as well as in the distant landscape, the varied and beautiful sky, and bright colours of every foreground, even of a muddy street; we have, moreover, "awful examples" of the violation of these laws in almost all the classes of manufactures which are in daily use. It is not sufficient that colours should be striking. Natural colours are not striking. Patches of light-blue stuck upon emerald-green or reddish-purple will be striking enough to

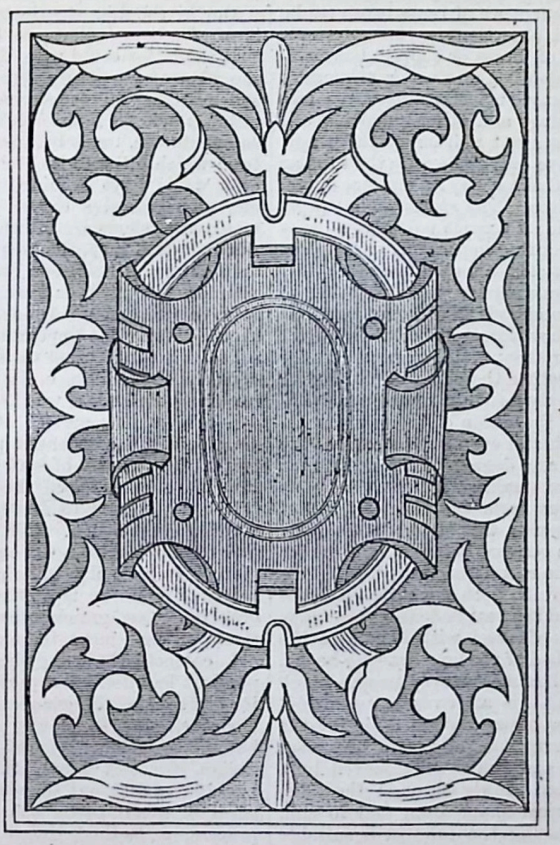
attract a vulgar eye; but these things will not satisfy the requirements of a refined and cultivated taste. Colours applied according to the strict law of complementary colours, with a due calculation of the power and depth of each tint, so that there are not many violent contrasts of light upon dark or dark upon light, will in the end produce agreeable effects. To judge from the specimens we constantly see, many binders think that the more contrasts, and the more violent these contrasts are, the nearer are their designs to the accomplishment of their wishes. A pattern in one light colour upon a dark foundation, or the reverse, with the assistance of a gold line, will be far more satisfactory than a gaudy variety of colour, a confusion of lines, and a meaningless mass of ornamentation. Simplicity of colour is certainly to be preferred in all cases where it is not necessary to have great richness, and even then great variety can only be introduced under the judicious guidance of those who first know how to use simplicity.

Line.—Much of what has been said about colour will apply to line also. A judicious and discriminating study of the works of the old binders will lead to great profit. Here also will be found great simplicity. Straight lines varied by curves, curved lines of all kinds working into one another, not a mere series of bits of circles patched together, but portions of ellipses and all the known mathematical curves, so far adjusted to one another as to seem the results of free-hand imitations of the works of Nature; these are the combinations which form the most pleasing designs. Straight lines and acute angles break the monotony of all these curved lines, the rectilineal and rectangular sides of the cover itself forming a great contrast to the whole.

In the central portion of each cover of more than ordinary pretensions we usually find a space formed with lines that should never be parallel to the ends of the book. On many of the most excellent of the Grolier bindings we have the general outline of an ellipse, a figure introduced even more distinctly in Figs. 2 and 3 on page 88. When the book is of large size and the design elaborate, care is taken to break the line of the ellipse just at the points where the axes would reach to the circumference. This is done with great judgment; at the sides the curves are led on to form a re-entering curve, and so, though in the inner line the eye is carried on almost smoothly, yet in the exterior part of the same figure other forms are suggested and left to the imagination to continue. Where, however, the curve is sharper by causing the continued line to overlap the curve, the line is broken more completely by a curve cutting right through the original line. In Fig. 1, page 89 (a Grolier), the central label presents six sharp points formed by curvilinear angles towards the centres of the long straight lines, and then again, as if to guard against the impression of a sharp point piercing the straight side, a kind of thick *buffer* is interposed, bounded by curves of a different character. A shield with a coat of arms may not ineffectually be used as a centre ornament, provided none of the sides are either rectilinear or approach that form. A diamond shape or rhomboid can be employed also, but the lines around it should be curved and suggest an oval.

The lines of the sides are strengthened by corresponding lines on the edge of the cover parallel to them; but these latter are placed at no great distance within the outer edge, sometimes with scroll-work between, but more frequently simply near the edge, and just within this the straight line is gradually curved off towards the line within it; or curves are brought to equal distances from the straight line, so that if increased in number they would almost suggest this species of line. Specimens of what we mean may be seen upon many of the examples given in this series of papers. At the corners the lines of the sides should not be simply curved round, as this is suggestive of decay in the book, when the sharpness of corners shall have worn away, and the leaves have become what is commonly called "dogs-eared."

It will be seen from this that what is required is a combination of simplicity and variety, a few main lines towards which the remainder point, straight lines by the sides, a central boss, some intermediate curves; but that the way in which these lines are indicated admits of immense variety of curve and combination.



RELIURE DE HARDY-MENIL.

These observations are sufficient for the present. There is much more to be said about the component parts of a good design; but it will be well to digest this first, to observe its application in the many examples which daily come before us, to note where designs fall short of these requirements, and how far this falling short does really detract from their beauty.

It may not be uninstructive, however, while turning away for a time from the further consideration of the leading principles of art in bookbinding, to take up the mechanical part of the process again, and to mention various means that have been proposed as substitutes for the system of sewing the sheets of a book together. The chief of these, which is called "Indian-rubber binding," was introduced by Mr. Hancock, and is not without its advantages for certain kinds of books. The first step in this process, after the sheets have been folded, is to cut the edges with the guillotine, that is used for this purpose, on all sides, back as well as front, which has of course the effect of separating all the leaves one from another. The leaves thus cut are then passed through a kind of gauge, by which the edges in front are brought into the form of a shallow groove, while a corresponding convexity is produced at the back. A piece of strong cloth or canvas is then fastened to the back by means of a cement in which Indian rubber forms the principal ingredient, and the leaves, hitherto without connection, are firmly fastened to the cloth backing and to one another. The union of the leaves having been thus effected, the book is then forwarded and finished in the usual manner. The peculiar advantage of this method of binding is the readiness with which the leaves of any book, however thick and bulky it may be, will open to the fullest extent, and lie perfectly flat, owing to the extreme flexibility of the back. This renders it a most useful mode of binding for certain classes of fine art work collections of music, maps, engravings, and letters and manuscripts of all kinds in which the writing may be carried so close to the edge of the paper that some part of it would be hidden from view if bound in the ordinary way. Attempts have been made to connect the sheets of a book by metal fasteners in various ways, but none of these possess the advantages of permanence and convenience presented by sewing, and the mode of cementing that has just been described.

GREAT MANUFACTURES OF LITTLE THINGS.—XIII.

CABINET BRASS-FOUNDRY (*continued*).

BY CHARLES HIBBS.

MOST of the articles comprehended in this category consist of two or more pieces, the initiatory form of which has been given to them by one of the two processes we have endeavoured to describe—namely, casting and stamping. The business of the finisher is to put these together, and combine them into articles of utility or ornament, ready for the market. There is, however, yet a third process, by which the parts of some articles are prepared for his manipulation; and without some notice of this our description would not be complete. The process alluded to is that of tube-drawing. We have already mentioned this as a distinct department of the trade, not necessarily connected with our subject, and so far as the manufacture of brass tubes (to be used *as* tubes) is concerned, that assertion is perfectly true. The production of seamless tubes of brass or copper, but principally brass, for the boilers of locomotive, marine, or stationary engines, amounts annually to many thousands of tons; and that of soldered tubes for gas-fittings and other purposes will easily be conceived to be enormous; but neither of these now call for our consideration. We have only to do with the tubular parts of cabinet brass-foundry, and these may be produced upon the cabinet brass-founder's premises. The stems of hat-pegs, the massive-looking rings that slide on cornice poles, the ornamental projecting handles of counting-house doors, etc., are tubes, as are also many other articles whose appearance less betrays their origin. When manufacturers were first led to substitute light tubes for heavy solid rods in different portions of their work, it is probable that they accomplished their object by simply bending and hammering sheet metal over an interior core or mandril, and soldering together the edges of the seam; but this method, which would only produce clumsy and imperfect work, is now superseded by the action of the draw-bench, which imparts a beautifully smooth and even surface, and at the same time reduces the metal to any degree of lightness that may be required. The method of making tubes is now as follows:—A strip or ribbon is cut from the sheet by roller-shears fixed at the proper width apart; this strip is afterwards passed under a pair of rolls which convert it into a long gutter spout, the round surface of the one roll fitting into the hollow of the other. A second pair of rolls, both concave, bend the edges over towards each other, and the rest is done by the drawing tool. This is a heavy block of steel with a hole in the centre, fixed upon the substantial bed of the long drawing-bench. The end of the tube is bent and hammered over in any rough way to pass it through this hole, and is afterwards "dubbed" or "tanged" outwards with a few blows to form a lip for the drawing pincers to hold. These grip it tightly, and being set in motion by a system of wheel and chain work moved by a winch, draw the tube steadily and slowly through the hole, forcing it to take a true cylindrical shape from end to end. The edges are then united by placing the tube in a suitable stove, the seam having been first plastered with wet solder, consisting of grain-brass and borax, as a flux. When cooled, it is again put through the draw-bench to smooth down inequalities, and is ready for polishing up. Should the tube, however, be required for any purpose that necessitates smoothness and accuracy of the interior, such as telescopic sliding motions, etc., it is passed through the tool again and again, a steel mandril being first inserted, which makes the inside as smooth as the outside. One advantage of this method is that the tubes can be made of shapes other than cylindrical by accommodating the hole in the block to the pattern required. They can be made square, triangular, or polygonal, or their surfaces can be ribbed or fluted according to fancy. By giving the nut, with the hole in it, a revolving motion while the tube is passing through, a beautiful twisted pattern can be obtained, and by turning it the reverse way during a second process a diamond ornament is the result. An improvement was introduced twenty years ago which rendered practically inexhaustible the variety obtainable in the ornamentation of tubes. Four rollers working together, the concave surfaces of which formed a complete circle when joined, received the tube after it had been perfected at the draw-bench, and impressed upon it the pattern which had been previously cut in their faces by the die-sinker's art. Very beautiful designs were produced by these means; indeed, the only limit lay in the taste and fancy of the artist.

For some purposes it was desirable to use tapering tubes, the diameter of which gradually diminished from end to end. Many were the contrivances invented to effect this, but none were satisfactory until the idea was hit upon of taking advantage of the ductility of two metals. A pattern of the drawing tool, with its orifice, may be made in any material, and casts are taken therefrom in block tin. One of these is fixed upon the draw-bench, and the tube, previously bent over, and still enclosing a mandril of the required shape, is inserted by its thin end. As the draw-pincers pull it through, the tin slowly and reluctantly expands with the pressure, still retaining and impressing its original pattern upon the tube. These moulds are good for one operation only, but they can be easily re-cast, and the first cost of them is but trifling.

During the first experiment of drawing tubes upon a mandril, it was discovered that the brass adhered so firmly to the steel, that the latter could with difficulty be withdrawn. This gave the idea of imparting strength to the tube, and at the same time effecting a great saving in cost, by drawing a thin coating of brass over an interior tube of iron. As soon as this method came into use, brass became applicable to a variety of purposes from which hitherto its yielding nature, and more especially its cost, would have excluded it, such as picture-rods, desk rails, etc. The massive curved bars which guard the plate-glass windows of shops are internally of iron, cut from the sheet, and drawn into a tube, the resplendent brass surface being only a thin veneer. Stair-rods are of solid iron, plated in a similar manner. The most curious application of the process, however, is to cornice poles, which, when fashion decreed that they should assume the appearance of heavy brazen furniture, were coated with thin brass to the extent only of about two-thirds of their circumference, the part which was out of sight still revealing the honest wood.

We have now arrived at the first process of finishing the articles whose component parts have been thus variously prepared. In the case of stamped work, the first step is to free it from the surplus metal that surrounds the edge of the design, it being necessary to leave a little to spare, in order to ensure a perfect impression. For this purpose a press is used, and a pair of clipping tools cut out the pattern clean at a blow. Some stampings have also to be pierced, the design, when completed, being of open or fret work, some of which is very airy and graceful. Our grandmothers affected pierced work, for decorative purposes, more than we do, as may be seen on many an old cabinet whose key-holes, and plates which support the pendent handles, have perforated designs of great elaboration, if not beauty. Finger-plates for doors, and bands for hanging curtains, were frequently of open work, and were sometimes backed by coloured metals to represent enamel. Where the design was not large, these perforations could be made by punches of different shapes, arranged in a press; but where the sheet of metal to be operated upon was too long for such a process, a method called "book piercing" was resorted to, similar to that which the writer remembers to have seen used in perforating the cards for Jacquard looms. Two plates were prepared by having the whole design cut cleanly through them, and between these the sheet metal was laid, as between the leaves of a book. A series of loose punches fitted into the upper holes, and the whole was then passed between a pair of rolls, which compressed the heads of the punches, and forced them through the intervening sheet.

The operations of turning, filing, screwing, riveting, etc., which form the staple of the brass-finisher's art, are so simple as not to require any explanation. The processes which call for description as being peculiar to the trade are mostly those which deal with the ductile quality of the metal, producing results which to the uninitiated would seem almost marvellous. In a former article on "Buttons," we explained that the tiny metallic ring, over which was stretched the little pieces of white linen to form a covered button, was made in the same way as are curtain rings, and gave a short description of the method. As it forms, however, a sort of representative operation in brass foundry, we will here take leave to describe it again, with such amplification as may be necessary. Any one picking up a brass curtain ring, might imagine that it had been

cast, or that it was a piece of wire bent round and soldered. If, from its lightness, a guess were made that it might be a tube, which it really is, the next puzzle would be that it had no apparent joint. Neither has it; the tube is an endless one, and no breach has ever been made in its circumference. It was first cut from a sheet of thin brass in the shape of a crown piece, and the middle was afterwards punched out of it, leaving merely a narrow circular rim, like the diaphragm of a photographer's lens. This was put under a press, and a pair of tools fitting into each other bent the rim into the shape of a circular gutter. A second and third pair of tools turned over the edges of the gutter to meet, and joined them completely, nor can the line of juncture be detected, except by the most critical examination. The metal has therefore been in some parts expanded, and in other parts compressed, and yet not the slightest puckering is visible upon its surface; it has yielded readily to pressure, and readjusted all its particles to suit the change of form. This facile disposition is taken the utmost advantage of in many another process that may be seen in a cabinet brass-founder's shop. Pieces of metal of the most enigmatical shape gradually assume forms familiar, under apparently the simplest manipulation, and the general impression on seeing brass worked for the first time is that anything may be done with it. Let us follow that heap of metal plates, about the size of the top of a tea-cup, which lie on the bench by the side of a powerful press, through all their stages of development, and see what they will become. First, the workman takes them one by one, places them over the hollow, of flattened circular form, which is cut in his bottom die, and brings down upon them a polished globular punch, which domes them up—in technical *parlance*, "raises" them—and they become so many shallow brazen saucers. Next, they are taken to another press, where another pair of tools deepen the concavity, and make them into half-globes. They will then require annealing afresh, and afterwards they are taken to another press, the bottom die of which has a circular hole cut right through it, with polished upright walls. Through this they are forced by the pressure of a descending punch, till they fall into a box below, by which time they assume the appearance of magnified castor-tops. Then they are subjected to the action of a pair of concave dies, fitting one upon the other, between which they are squeezed into the semblance of hollow flattened balls, with an opening of, say, an inch in diameter, on the upper side. The metal is not creased or puckered in the least degree, and is as smooth as when it was cut from the sheet. Meanwhile, another workman has been dressing up and preparing some cast pieces, somewhat pulley-shaped in form, in a lathe, and has cut round one edge of them a nick with a V-shaped turning tool. Another pair of dies, similar to the last, only a trifle smaller in their concavities, come now into operation. The lower one has a recess cut in the bottom of its hollow, and in this the pulley is inserted, its nicked rim just peering above the top of the hole. The brass ball is then placed over it, mouth downwards; the upper die descends upon it, encircles it, and compressing it all round, forces the edges of the narrowing mouth into the nick of the pulley, thenceforth to hold it with an unrelaxing grip. The press is raised, the combined article is taken from its bed, and there is the familiar door-knob, which perhaps, till now, you had innocently thought was a solid lump of metal. You try to shake it, to see if the juncture which has been effected is sufficiently firm for the practical purposes of a knob: the chances are that it will not move in the least; but if it do, the next process will tighten it, and that effectually. The neck is again held in the lathe, the workman presses for an instant the point of a burnishing tool against the outer lip of the nick, the metal immediately closes its grasp, and the union is perfect. While he has it there, he skims over the rapidly revolving surface with a sharp tool, and takes off the "scale," leaving the knob bright and smooth, ready for the burnisher.

Let us again follow these pieces, which, cut in the first place like the others, as circular discs from the sheet, have been "raised" into the form of shallow patty-pans. They are also "drawn down" through the hole of a lower die, until their sides are upright, and then the bottom is cut out, leaving merely a hoop of metal. This is placed between a pair of tools which are cut into hollowed circular wedge form, and they curve the sides of the hoop outward on both edges, making the circumference a shallow groove. A second pair of tools further compress the metal and deepen the indenture, but there has been first placed between them a little cast ornamental piece, which the squeezed metal lays tight hold of, and forthwith comes out a neat little pulley, it may be for a blind-roller, it may be for the hanging weights of a sliding chandelier. In like manner, surprises await the inquisitive on-looker at every turn. He will see a length of tube being wound upon a short, stout pole like a coil of rope. He wonders why it does not flatten or "crink," and is informed that it has been filled first with sand, to keep it in shape. When the pole is full, he will see a clean cut made with a saw across all the coils, and instantly they appear as cornice rings, all but the soldering of their several ends together. He will see workmen at the lathes deftly turning the ends of bell-pulls, scooping out a cup-like recess, inserting therein a piece of beautiful porcelain or glass, turning over the light metal edge with the pressure of the tool, and enclosing it like a jewel in its setting. Forms of beauty will grow under his admiring gaze, combined of the most unlikely materials, and not the least part of his astonishment will be caused by the quickness with which the whole thing is done, and the dexterity of the educated fingers, that move more rapidly than the eye can follow. He will also be struck with the economical division of labour that seems to prevail in all branches of the industry, and the classification of different kinds of work. Thus, in one shop "tack work" alone will be carried on, which means brass-headed nails, hooks, sash and drawer knobs, and little things of that sort. Each article has an iron screw or spike as a part of its anatomy, fixed there immovably by having been placed in the mould for the melted metal to enclose it, and this constitutes it tack work. In another shop "spring work" is the speciality, that is, any articles in which springs are introduced, as blind-cord racks, cupboard bolts, bell furniture, etc.; and in a very large manufactory each one of these articles would form a separate branch.

When brass articles have been turned, filed, or otherwise dressed, they are ready to undergo the process of dipping. We have said something of this when treating of buttons, and have only to add a description of the peculiar method of "dead" dipping, which produces a beautiful frosted appearance on the work, and enables variety to be given by burnishing or brightening up prominent parts. The secret of dead dipping was first discovered by accident. A dipper had, through negligence, left a quantity of work all night in the "pickle," or cleansing solution, which consists of weak diluted aquafortis; and the consequence was that on immersion in the stronger liquid in the morning, it would not come bright as usual, but presented a dull dead surface like that of ground glass. The effect was pleasing, and dead dipping has been the fashion ever since. The *modus operandi* differs, however, from that hit upon by the careless workman. For bright dipping, a single immersion for an instant in the sharp acid is sufficient. A reciprocal action then takes place, the chemical nature of which we must leave others to explain, but some part of the acid is taken up by the metal, and at the same time some part of the metal is left behind in the acid. In course of time the acid will become so impregnated with brass that its action will be sluggish, in which state it is just in the proper condition for dead dipping. The workman immerses the articles several times in this solution, until the acid no longer "bites" the metal, but rolls off it like water, by which time the frosted surface is produced. After dipping, all articles are swilled, the first time in a vessel filled with water, the second in a running stream; and as, after many swillings, the water in the vessel becomes too strongly tinged with acid, it is taken away to be used for "pickle." An alkaline solution is used for a final dip, in the case of articles whose joinings might accidentally contain a little of the insidious acid, which is thus killed.

The next process is burnishing, which again requires little description. Steel tools are used, instead of the stone ones affected by button burnishers, and these are of various shapes, pointed, hooked, or with "spade" or ball" terminations, to suit the different forms of the work. As the burnisher must have a solid surface to work upon, he requires, in the case of thin stamped work, to be furnished with a lead force, or casting from the die, in order to support it internally in all its parts.

The last operation is "lacquering," which simply means coating the articles with a transparent varnish to protect them from oxidisation. The varnish is composed of seed-lac dis-

solved in spirits of wine, sometimes a little turmeric or dragon's blood being added to give richness of colour. When this is applied, by means of a camel-hair brush, to the warmed bright surface of the metal, the spirit quickly evaporates, and leaves a thin film of the gum behind, which will adhere firmly to the brass, and withstand all fair usage for years. The art of good lacquering consists in coating the surface evenly, so that no smears or joins may be visible, the difficulty being greatly enhanced in the case of large articles, on account of the rapidity with which the varnish dries up under the influence of heat. A great deal depends upon the articles being uniformly heated, and suitable stoves are required for the purpose. The temperature of the lacquering shop is, for this reason, uncomfortably high.

The curiosities of the brass trade are many. One consists in the manufacture of brass rings for adornment, which form the jewellery of the native African. Wherever commerce has penetrated that mysterious continent, there the products of the Birmingham brass-foundry will be found in the most ludicrous connection. Dr. Livingstone describes the costume of a Makokolo lady as consisting entirely of brass rings and beads, which she arranged as follows:—Eighteen solid rings, as thick as a finger, upon each leg; nineteen similar ones on the left arm, and eight on the right; besides three rings of copper under each knee, and an ivory ring above the elbow. An order once reached Birmingham for 20,000 dozen of these "bangles," consuming in their manufacture 23½ tons of brass. Rings and coils of thick brass wire not only form the personal ornaments of the African gentry, and the criterion of their wealth, but they are also used as a medium of exchange. Great quantities of a species of money, called "Manilla," were once produced in this country, and exported to Africa, as also brass coins, with rude image and superscription. Should the researches of the great traveller, whose name is a household word among us, prove that a larger part of that country can be opened to our trade, we may expect "a good time coming" for Birmingham brass-workers.

TECHNICAL DRAWING.—XCII.

DRAWING FOR METAL-PLATE WORKERS (*continued*).

THE term *dome* is applied to the covering of the whole or part of a building. The Germans call it *dom*, and give the name to the cathedral or principal church in a city, although the building may not have a spherical or polygonal dome. From this and other circumstances it is inferred that the term is derived from the Latin *domus*, a house.

The following definition is given by Mr. Peter Nicholson, to whose excellent works we are also indebted for the illustrations of this branch of our subject:—

"A dome is an outer or vaulted roof, springing from a polygonal, circular, or elliptic plan, presenting a convex surface on the outside, or a concavity within, so that every horizontal section may be of a similar figure, and have a common vertical axis. According to the plan from which they spring, domes are either circular, elliptical, or polygonal. Of these the circular may be spherical, spheroidal, ellipsoidal, hyperboloidal, paraboloidal.

"The word *dome* is applied to the external part of the spherical or polygonal roof, and *cupola* to the internal part. Cupola is derived from the Italian *cupo*, deep, whence also our word 'cup;' but 'cupola' and 'dome' are often used synonymously, although perhaps incorrectly. Such as rise higher than the radius of the base are denominated *surmounted* domes; those that are of a less height than the radius are called *diminished* or *surbased;* and such as have circular bases are termed cupolas."

The forms named above, "hyperboloidal" and "paraboloidal," will be understood on constructing figures of a hyperbola and parabola, which would be the vertical sections taken through the axes of the domes referred to, and these domes would be generated by each of these sections rotating on its axis.

Thus, if a piece of cardboard be cut into the shape of the parabola, and a wire or thread inserted so as to form a vertical axis, then if the student, holding this string or wire, blows against the edge of the piece of card, he will, as it whirls round, see the paraboloid or solid parabola generated.

Fig. 672.—*Given the plan of a square dome, and one of the axis-ribs at right angles to the sides, to find the curve of the angle-rib and the covering.*

The axis of a square dome is the vertical line in which the diagonal planes would intersect each other.

Let A B C D be the plan of the dome, and A C and B D the intersections of the diagonal planes. E F is the base and E K the height of the given rib; and the curve line K I H G F the section of the upper surface which comes in contact with the boarding.

The student will realise this if he imagines the point K raised, so that it is over E, the quadrant E F K thus becoming vertical.

Produce E F to *k*, divide the curve line K F into any number of equal parts, and it will be understood, as the operation progresses, that the more points taken, the more correct will be the result.

Set off the parts F G, G H, H I, I K, upon the straight line F *k*; the first from F to *g*, the second from *g* to *h*, the third from *h* to *i*, and the fourth from *i* to *k*. Through *g*, *h*, and *i* draw lines parallel to A D. From the points G, H, I, in the curve of the given rib, draw G G′ N, H H′ O, I I′ P parallel to A D, cutting the base of the rib E F at the points G′, H′, I′, and the half diagonal D E at the points N, O, P.

Take the intercepted parts G N, H O, I P, between E F and E D, and apply them successively to the lines parallel to A D on each side of F *k*.

This is best done by drawing perpendiculars from I, H, G, cutting the lines drawn through *g*, *h*, *i* in *n*, *o*, *p*.

Draw through these points the curve A *n o p k*.

Measure on the other portion of the lines from *g*, *h*, *i*, the widths *g n*, *h o*, *i p*—viz., *i p′*, *h o′*, *g n′*, and draw *k p′ o′ n′* D.

Then the space contained between A K D will be the form of the lead or zinc required to cover the one quarter, A E D, of the dome.

To find the hip-line of the angle-rib, the base of which is E D.

From the points N, O, P, E, draw N Q, O R, P S, and E T perpendicular to E D. Make these lines successively equal to G′ G, H H, I′ I, and E K; and through the points D, Q, R, S, T draw a curve which will be the hip-line.

To draw the angle-rib and covering of an octagonal dome.

Fig. 673 is the plan of the octagonal dome, showing also the given rib.

Let A B C D E F G H be the plan, and let L O K be the given rib—that is, the rib passing to the apex, at right angles to the side A H.

Divide the arc L K into any number of equal parts, as *a*, *b*, *c*, and draw the radius A O.

From *a*, *b*, *c* draw lines parallel to O K, and cutting A O in *a′*, *b′*, *c′*.

From *a′*, *b′*, *c′* draw lines at right angles to A O, set off on these the lengths of the perpendiculars in the given rib similarly lettered, measuring from the line L O to *a b c*. Then through the points M, *c″*, *b″*, *a″*, and A, draw the curve which will be the form of the angle-rib.

Now to find the covering of one side of this dome.

Draw a perpendicular at L, and set off on it the lengths *a″*, *b″*, *c″*, M, measured from the curve of the angle-rib, and through these points draw horizontals.

Intersect these by perpendiculars from *a′*, *b′*, *c′*, and the points so obtained will be those through which the required curve is to be drawn, as in the last figure. The same measurements set off on the horizontal lines from the central perpendicular will give the other side of the covering.

Fig. 674 shows the method of finding the form of the covering without drawing the whole plan.

To find the hip and rib parallel to the longitudinal side of an oblong building, also the covering of the sides of the dome, the plan and rib parallel to the shorter side being given.

Fig. 675.—Let I J L K be the plan, and let A B be the given rib.

Divide the curve A B into any number of equal parts, 1, 2, 3, and draw the diagonals I L and J K.

From 1, 2, 3, draw lines parallel to I K, cutting A G, the base of the given rib, in 1′, 2′, 3′, and passing through G K.

Through the points of intersection in G K draw lines parallel to K L, passing through G E, the base of the required longitudinal hip, in *f*, *e*, *d*, and through G L in *h*, *i*, and *k*.

Make *f c*, *e b*, and *d a* equal to 3′ 3, 2′ 2, 1′ 1, and draw the curve E *a b c* A, which will be the form of the hip parallel to

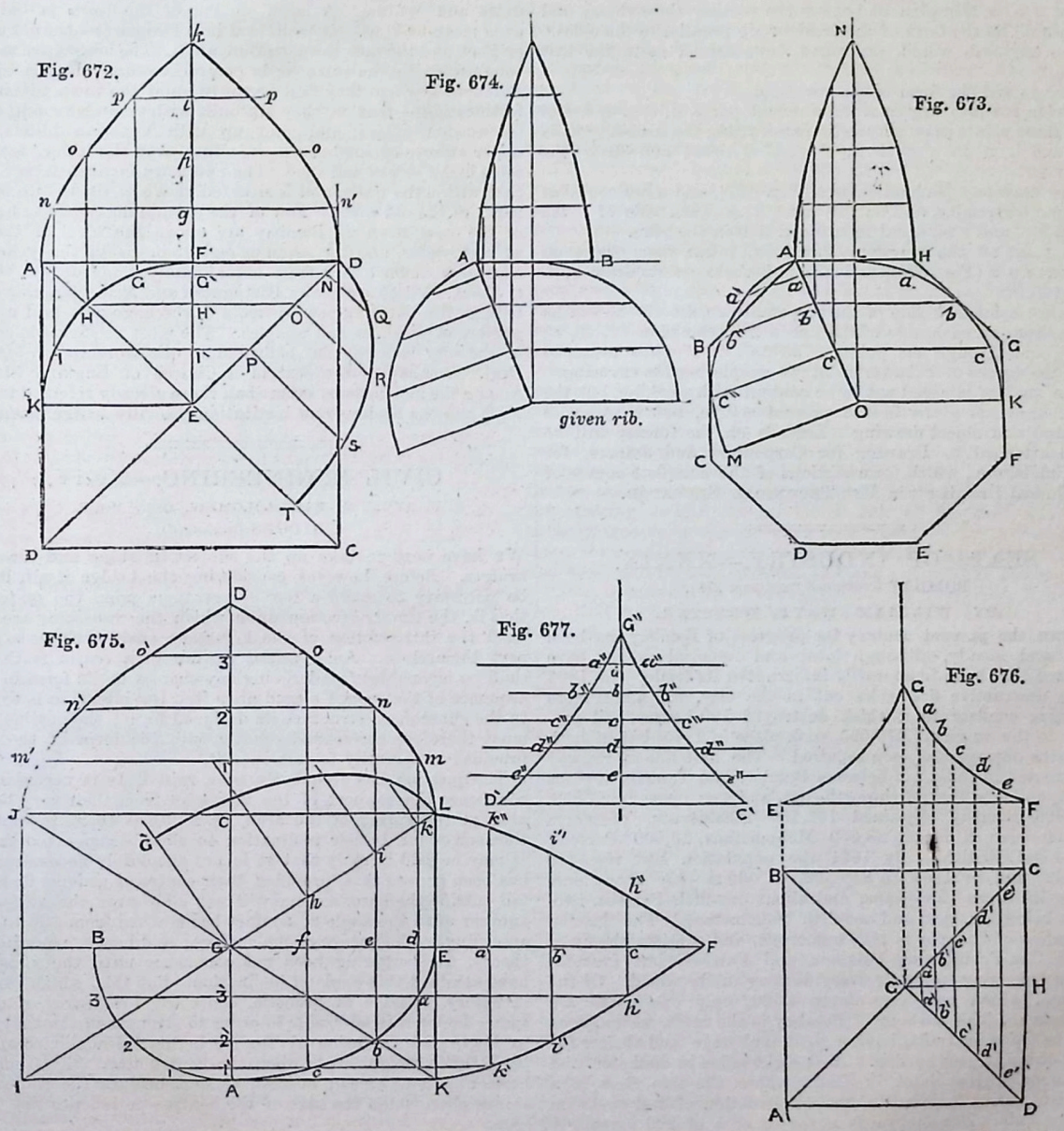
the long side of the plan—viz., starting from E at right angles to K L. We now proceed to find the form of the angle-rib—viz., that of which L G is the plan.

From G, *h*, *i*, *k* draw lines perpendicular to G L.

Make the perpendicular at G—viz., G G′—equal to G B; make those on *h*, *i*, and *k* equal to *f c*, *e b*, and *d a* respectively; and draw the curve G′ L, which will be the form of the angle-hip.

It is now necessary to find the covering of the dome. To find that of the longitudinal side, through G draw A C, parallel distances on the other side of the central line—viz., *h*″, *i*″, *k*″. From F draw the curves through these points, thus completing the development.

Now, to make the form of the whole of this still more clear to the learner, let us suppose the figure carefully drawn to a much larger scale, on a piece of stiff drawing paper or cardboard. Cut with a penknife through the curve A B, through the lines B G and G A, and place the quadrant upright on its edge A G, securing it by gumming a piece of paper under the corner-piece I.



to I J and K L, and produce it indefinitely; from C mark off on this line 1′, 2′, 3′, D, equal to 1, 2, 3, B on the original rib A B, and through these points draw horizontals, which cutting the lines passing though *h*, *i*, *k* (parallel to K L), will give the points *m*, *n*, *o*. Set off on the opposite of C D, the widths 3′ *o*′, 2′ *n*′, 1′ *m*′, equal to 3 *o*, 2 *n*, and 1 *m*, draw the curves D *o n m* L and D *o*′ *n*′ *m*′ J, then J D L will be the required covering.

Now produce G E (the line parallel to I K) indefinitely, and from E set off on it the lengths *a*, *b*, *c*, A, taken from the rib E A, thus obtaining the points *a*′, *b*′, *c*′, F, and through these draw lines parallel to K L.

Produce the lines 3′ *a*, 2′ *b*, and 1′ *c* until they meet the lines drawn through *a*′, *b*′, and *c*′, in *h*′, *i*′, *k*′; set off the same

Now cut through the curve A E, and at the back cut half through the thickness of the line G E, and bend the piece A D upwards until it is perpendicular to the surface of the drawing.

In the same way cut through the curve L G′, and the line G G′ and half through the line L G, and bend up the figure L G G until it is vertical.

Then it will be seen that the points A of the one rib, B of the other, and G′ of the third, will meet at one point, the three lines G A, G B, and G G′ uniting in one perpendicular, and these would then be the forms of the respective roof-trusses.

Now cut out the curves J D L and L F K, and it will be seen that these pieces will exactly cover the ribs in the form required, D meeting F on the point G (in which A and B are also united).

As by this method the curve L G′ cuts into the covering L I J, and there are other little inconveniences arising from making such a model out of one piece, it is advisable to make the three ribs out of separate pieces, and to gum them on the plan, using strips of linen by way of hinges; they can then be raised or laid down flat at pleasure.

Fig. 676.—This figure gives the plan and elevation of a pyramidical roof, the plan of which is square, and the surface of which curves inwardly.

A B C D is the plan and E F G the section through G′, and this would be the form of the truss or rib parallel to the sides.

The angle-rib would, of course, be obtained as in the last figure.

Now to find the form of the covering.

Divide F G into any number of equal parts, *a*, *b*, *c*, *d*, *e*, and from these points draw perpendiculars cutting the semi-diagonals G′ C and G′ D in *a′ a′*, *b′ b′*, *c′ c′*, *d′ d′*, *e′ e′*, and draw the line G′ H.

Now draw any perpendicular, I (Fig. 677), and a horizontal at its lower extremity, and on this set off on each side of I the length I C′ and I D′, equal to H C and H D in the plan.

On I set off the lengths *e*, *d*, *c*, *b*, *a*, taken from those on the curve G F (Fig. 676), and through these points draw horizontal lines.

On these, on each side of the perpendicular, set off the widths of the lines on each side of the line G H in the plan (*a′*, *b′*, *c′*, *d′*, *e′*), and through the points *a″*, *b″*, *c″*, *d″*, *e″* thus obtained draw the curves G″ C′ and G″ D′, thus completing the covering.

The student is urged not to be content with working out the linear drawings given in the present course, but to practise freehand and object drawing. Lessons on the former will be found attached to Drawing for Carpenters and Joiners, for Machinists, etc., which form sections of the complete course of "Technical Drawing" in THE TECHNICAL EDUCATOR.

SEATS OF INDUSTRY.—XXXIX.

BOMBAY (*continued from page 279*).

BY WILLIAM WATT WEBSTER.

DURING the present century the progress of Bombay has been rapid and steady, although local and imperial events have occurred that have temporarily interrupted its trade. In 1803 a very destructive fire broke out in the city, and a still more extensive conflagration, which destroyed 190 houses, and property to the value of £70,000, took place in 1845, but in both cases the damage was soon repaired. The first line of railway constructed in India ran between Bombay and Tannah, a place twenty miles to the north-north-east, and was opened in 1853. In 1816 Bombay contained 161,550 inhabitants, of whom 104,000 were Hindoos, 28,000 Mahometans, 13,000 Parsees, and 4,000 British. By 1861 the population had risen to 566,119, and in 1864 to 816,562, of whom only about one-hundredth were Europeans, and about one-fifth Parsees, two-thirds being Hindoos, and one-fifth Mahometans. The floating population of the city is very numerous, and consists chiefly of Arabs, Goa-Portuguese, Persians, and Parsees, but includes sailors belonging to nearly every country in the world. Of the garrison, which numbers about 4,000, only one-fourth are Europeans. The harbour of Bombay is the most commodious and the safest in India, having good anchorage and shelter for fleets of the largest burden. It is eight miles in diameter, and is the only great inlet in India where the tide rises to a sufficient height to permit of the construction of wet docks on a large scale. The dockyards cover an area of 200 acres. A more extensive trade is carried on between Bombay and China than between the latter country and any other of the Indian Presidencies. The exports to China, which in 1862 amounted to upwards of £6,000,000 in value, consist principally of raw cotton, opium, pearls, sharks' teeth, fins, fish maws, sandal-wood, etc., and the imports into Bombay from that country are chiefly silk piece-goods, spices, and treasure. From Great Britain Bombay receives annually about £8,000,000 worth of cotton and woollen stuffs, cotton yarn, hardware, ironmongery, and other articles, and in exchange sends to this country upwards of £10,000,000 worth of raw cotton and other native wares, and of silk, spices, etc., collected at the port from China and other countries. Besides Britain and China, Bombay carries on a large trade with the ports of the Arabian and Persian Gulfs and the Malabar coast, and with Calcutta, Cutch, and Scinde. The total value of the exports from Bombay in 1862 was £18,622,462, while the total imports amounted in the same year to £9,468,965. There entered the port of Bombay in 1861, 3,163 vessels of an aggregate burden of 170,863 tons, and 2,814 vessels of 169,546 tons burden entered in 1862.

The town of Bombay cannot boast of any striking Oriental magnificence, and in this respect it presents a contrast to Calcutta and Madras. A large portion of the town is old and even mean-looking. It is divided into two parts—the old town, or Fort, and the new town, or Dungaree. The houses are mostly constructed in the same style of architecture adopted by the Portuguese when they first began to build the town within the fortifications—that is, they are built with verandahs supported by wooden pillars, and shut up with Venetian blinds, the upper storeys of the houses projecting over the lower, and the roofs being sloped and tiled. The new town is much larger than that within the walls, and is situated on a low, damp site to the north of the old town. Few of the ground-floors of the houses in the new town of Bombay are above the level of the sea at high water, and for seven or eight months in the year the occupants suffer either from actual inundations or the effects of them. There are many Portuguese and Armenian churches, both in the old and new towns, a few synagogues, and a vast number of mosques and temples. The most remarkable edifice in the city is a pagoda dedicated to the worship of Momba Devi. Bombay is the seat of a Church of England bishop. Among the institutions, other than those already referred to, the Mint and the Elphinstone Institution specially deserve mention.

CIVIL ENGINEERING.—XXIV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

WE have next to take up the subject of stone and masonry bridges. Before, however, considering the bridge itself, it will be necessary to make a few observations upon the *centering*, that is, the timber erection upon which the voussoirs are laid until the introduction of the key-stone enables them to support themselves. An essential feature in a *centre* is that it shall be incapable of undergoing any change in its form in consequence of the weight placed upon it. Its intention is to give to the subsequent structure its designed form; the outline of it must therefore correspond exactly with the form of the arch intended temporarily to rest upon it.

The question has frequently been raised, Is it necessary to commence the support of the voussoirs from their very beginning at the spring of the arch, or to leave them to support themselves until their inclination to slide becomes too great? It may be said in reply that it is not absolutely necessary. It has been proved that, provided their centre of gravity does not fall outside the base, a stone will not slide over the surface of another until the angle of contact has reached from 30° to 45°, according to the nature of the surface; and hence, according to theory, the centering need not commence until the voussoirs have attained this angle of inclination. But this, which is good in theory, is false in practice, expecially for arches of great span: hence it is advisable in order to strengthen the tie-beam, to begin the centering at the springing, although comparatively little weight rests upon the centre until 30° from the horizontal is attained; in some ancient bridges the projecting stones upon which the base of the centres rested are yet to be seen.

An Italian engineer, M. Lorgna, has suggested the arrangement of timbers shown in Fig. 71, for a centre, but it is not a suitable form, as the upright posts A B, C D, being themselves unsupported, can afford no real support to the diagonals *a* B, *b* B, *b* D, *c* D, which rest upon their haunches.

In order to find how best to combine the timbers so as to afford the greatest amount of support to the voussoirs, it is necessary, first of all, to determine the position of the tie-beam. This may be done as follows:—

From the points A and B (Fig. 72) draw the tangents A T, B T. Bisect B C at O, and draw the line T O, from the intersection of the tangents; the point D will be the position of the tie-beam. Divide A D into two or more equal parts, according to its

length, and let fall perpendiculars to the curve upon the tie-beam; these perpendiculars, $a\ b$, $a'\ b'$, will represent the position of intermediate king-posts. Through the points b, b', draw the lines A b B and A b' C; these will become the position of inclined beams to support the tie-beam at $b\ b'$, and the top of the king-post A K. The remainder of the arc below the tie-beam may be divided into as many equal parts as the length requires,

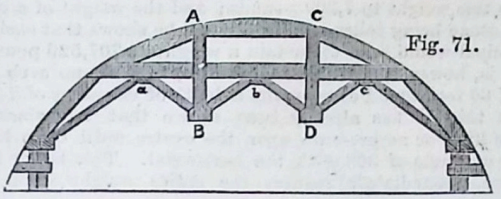


Fig. 71.

and through these points binding pieces, E e, F f, are to be passed, being perpendiculars to the curve, and resting upon the strut. This arrangement with modifications will answer for every form of arch.

We have stated that the voussoirs exercise little or no pressure upon the centering until their surfaces of contact attain an angle of from 30° to 45°. After this point each successive stone will press with increased weight upon the timbers. The relation between the weight of a voussoir and its pressure upon the centering, in a direction perpendicular to the curve, may be determined by the following equation:—

$$W\ (\sin.\ a - f \cos.\ a) = P;$$

where W is the actual weight of the voussoir, P its pressure upon the centering, f its friction with the next lower stone, and a the angle which the lower surface of the stone makes with the horizon. Hence, with an average friction—

If a = 34°, P = ·04W.	If a = 42°, P = ·21W.
If a = 36°, P = ·08W.	If a = 44°, P = ·25W.
If a = 38°, P = ·12W.	If a = 46°, P = ·29W.
If a = 40°, P = ·17W.	If a = 60°, P = ·54W.

When the surface of the stone becomes so much inclined that a vertical line passing through its centre of gravity falls outside

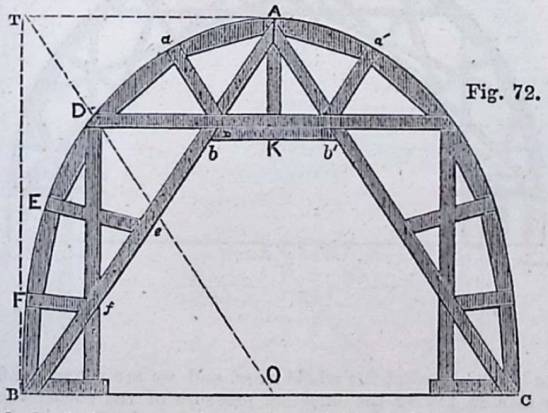


Fig. 72.

the bed of the stone, the whole weight of the stone may be regarded as resting upon the centering.

Perronet omitted the tie-beam altogether, as shown in Fig. 73, imagining that when the timbers were prolonged they found some of their support in the opposite sides of the arch. Such a centering, however, requires great care in the loading.

The centering adopted by the Swiss engineer, Labelye, for the old bridge at Westminster, is a good illustration. It is shown in Fig. 74. Two timbers resting on the abutments incline, and meet at the top of the arch. These form the main supports, and are braced in various directions.

When intermediate bearings can be found for a centre upon the bed of the stream, much of the difficulty attendant upon its construction is avoided. A simple arrangement of timbers with such supports is shown in Fig. 75. An arch of 130 feet span has been erected upon such a centering.

It has to be remembered that in all centering, of whatever construction, it has to be removed after it has fulfilled its duty of supporting the superstructure until the latter can support itself. The weight of the masonry would, however, entirely prevent the removal of the centre as a whole, unless some means be adopted to ease it away gradually from the masonry. The usual course is to insert wedges between the main outer surface of the centre, and the cross-beams upon which the voussoirs actually rest. These wedges can then by suitable appliances be removed one by one, and the cross-beams being then released, the centering can be removed bodily.

Inclined timbers or struts might be made use of for this purpose, but the bearings afforded by them would be neither so numerous nor so uniform as the wedges, one or more of which may be inserted beneath each voussoir.

Smeaton designed a very excellent centering, which was employed in the erection of the Coldstream Bridge. It is represented in Fig. 76, and is seen to consist of a tie-beam with upright posts and diagonal supports. In this case, however, the tie-beam was supported intermediately.

The centering employed by Rennie in the construction of Waterloo Bridge was admirably contrived. The span of each arch is 120 feet, with a versed sine of 32 feet. It was necessary in designing the centering to keep as clear as possible of the tide-way, and Fig. 77 shows how well this was effected.

The voussoirs were supported by cross-timbers which rested upon wedges introduced upon the heads of the inclined beams. The fact that the form of the arches in this bridge has undergone no change, is an evident proof of the excellent manner in which the centres were framed.

In the specification for the centres of the arches of the present London Bridge it states:—"There are to be four complete sets of centres, on which the arches are to be turned; each set of centres is to consist of eight ribs properly braced together, and to be executed according to the drawings; they are to be composed of the best Dantzic, Memel, Riga, or Stettin fir timber, except the springing pieces, which are to be of elm, and the striking wedges are to be of oak of the best quality, entirely free from sap or wave, and cased on the upper and lower sides with fine sheet copper, one-tenth of an inch thick, and to be well greased previous to being put in their places.

"The iron-work to be composed of the very best English iron, and to be executed as described in the drawings; the supports or trussels for carrying the centre to be of the best fir timber, of the quality above described; the trussels and centres when fixed to be firm and strongly braced longitudinally and diagonally, so as to make them firm and secure.

"The covering of the centre for carrying the arch-stone is to be of good sound fir, half timber, seven inches thick, to be carefully laid, properly levelled, and firmly packed and wedged up to the curvature of the respective arches."

It may be noticed here that the specification just quoted from mentions that there are to be *four* complete sets of centres. Now the object in having more than one set, which, when done with at any particular arch, might be removed to the next, is that it would be both unwise and dangerous to remove a set of centering in a bridge consisting of more than one arch, until the piers or buttresses upon which the stone-work abuts are supported upon the opposite side, either by the earthwork in the case of the buttresses, or by a completed arch in the case of the piers, in consequence of the side-thrust exercised by the materials, and which only commences when the centering is removed. Hence, in a bridge consisting of many arches—as, for instance, New London Bridge—it is usual to retain the centres in several finished arches, and to remove them in the first instance from the arch most removed from the unfinished end, by which arrangement the proper amount of support is ensured the piers.

The centering for the beautiful bridge over the Dee at Chester, which consists of a single arch of 200 feet span, consisted of six ribs in width. The span was divided into four spaces by three temporary piers at regular distances built up in the bed of the river, from each of which the supporting timbers spread like a fan towards the soffit, and making a perpendicular to the curve of the arch at the point of contact. The lower ends of these supports rested upon cast-iron shoes placed on the top of the piers, and the upper ends were bound together by two thicknesses of 4-inch plank cut to the form of the arch. On these were laid the covering, 4½ inches thick, which was supported over each rib by a pair of wedges 16 inches long and 1 foot broad, tapering about 1½ inches. Each course of voussoirs

had six pairs of striking wedges. The horizontal timbers of the centre were 13 inches deep, and the six ribs were tied together transversely near the top by bolts of inch-iron. The timber employed was fir, and the quantity required about 10,000 cubic feet.

A useful form of centering is given in Fig. 78. It was employed in a railway bridge over the Ouse, near York.

The piles upon which it rested were based upon the feet of the piers themselves, being inclined outwards.

In the bridge at Neuilly the principals of the centering are only 6 feet 6 inches apart, but they were found to be too weak. Each principal had seven or eight of the timbers composing it split throughout their whole length; others became bent, and their extremities were forced into the faces of the binding pieces. The result was a settlement of the arches. To counteract this as far as possible, the greatest speed was used in carrying on the work, and as it proceeded the centering was strengthened by braces extending from one principal to another, and by placing struts between the opposite courses of voussoirs. The openings in the framing were caused by the timbers not bearing equally against the binding pieces throughout the whole surface of their extremities, and this defect was attempted to be remedied by cutting the ends into a curve. This precaution did not, however, prevent penetration, but it did prevent the splitting of the timber; it also increased the play of the framework, and rendered the centres more liable to change their form.

In forming the centre of a bridge, the weight should be equally borne throughout, and the parts should be made sufficiently strong to support any portion, or the whole of the pressure it has to bear; and it will be found of the greatest value, wherever timbers abut end to end, to employ a socket of iron, as was done in the case of the centres of Waterloo Bridge.

The arrangement for the centering of a tunnel will be treated of under the head of railways.

M. Pitot has gone carefully into the subject of centres. He directs attention, in the first instance, to a determination of the effort which the centre has to make in resisting the pressure at its various parts; and what it will have to bear at different stages of the work, as the various courses of voussoirs are added. He assumed an arch of 60 feet span, of a semi-circular form, with the depth of voussoirs equal to 7 feet, and calculated what should be the scantlings for the centre of such an arch, the timber being of oak. He states that a square inch of oak will safely carry 8,640 pounds; but to be on the safe side he reduces this weight to 7,200 pounds; and the weight of a cubic foot of stone being taken at 160 pounds, he shows that each rib or principal would have to sustain a weight of 707,520 pounds.

This is, however, too high in practice, because no arch of a span of 60 feet would ever require a depth of voussoirs of 7 feet. Besides this, it has already been shown that the voussoirs exercise little or no pressure upon the centre until their joints assume an angle of 30° with the horizontal. This latter fact, therefore, immediately reduces the entire weight upon the centre by one-third of the whole mass, and we are consequently quite safe in taking the effective pressure of the voussoirs as equal to about 500,000 pounds resting upon each rib.

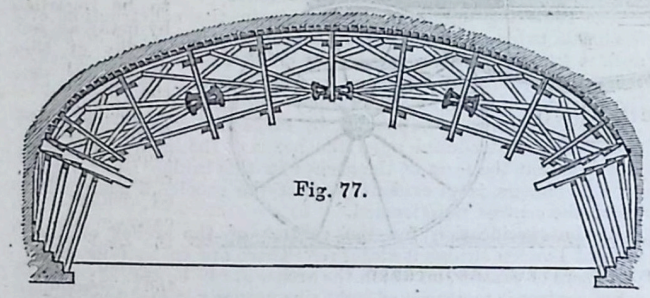


Fig. 77.

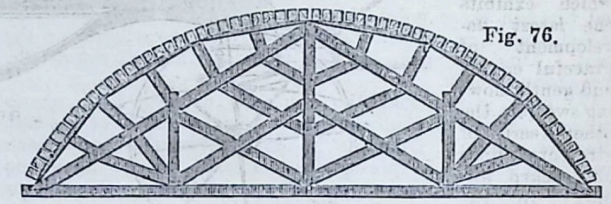


Fig. 76.

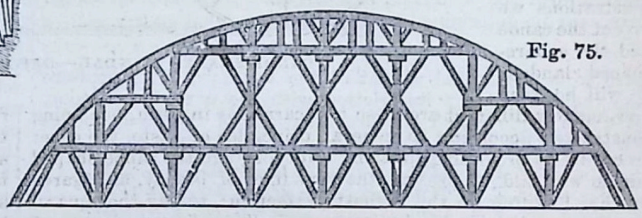


Fig. 75.

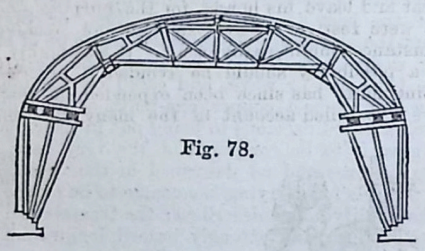


Fig. 78.

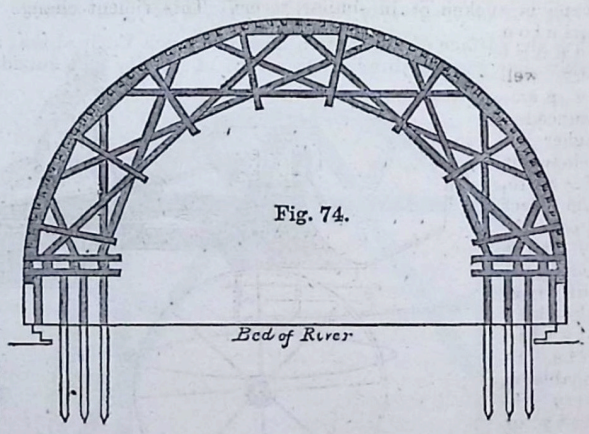


Fig. 74.

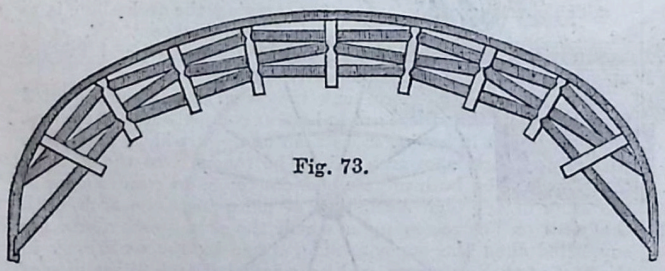


Fig. 73.

The dimensions of the timbers of each rib were as follow:—The exterior curve, corresponding to the intrados of the arch, was in several lengths, no part less than 12 inches wide, and 6 inches thick, framed and bolted together. The horizontal tie-beam consisted of one main beam extending across the entire span, strengthened in the central part by a second beam. Each of these was 12 inches square. The king-post was 12 inches square; the upper struts 10 inches by 6, and the lower 10 inches by 8.

A centering of these dimensions, constructed of oak, would afford a practical strength equal to upwards of 3,250,000 pounds, which we have shown is very far in excess of the weight it would be required to bear. It is true that we have assumed in the above that the timbers are so placed as to support the weight perpendicularly; but as this is not the case, we must reduce the effective support rendered to the arch by such a centre to about 2,850,000 pounds, or more than four times what is required of it.

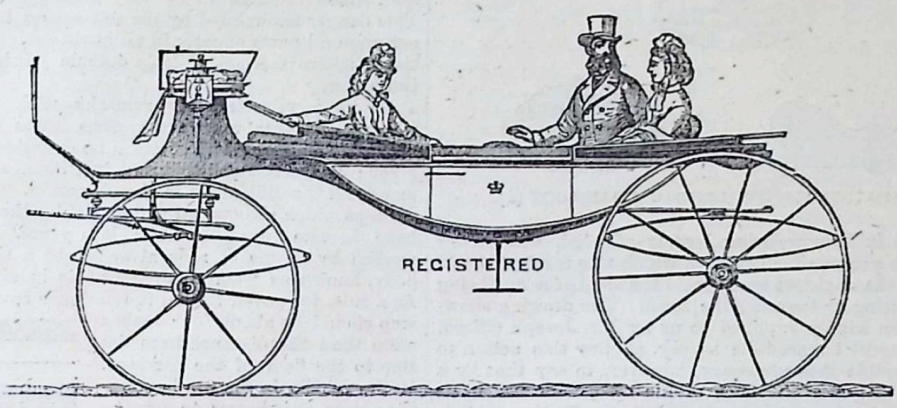
ENGLISH CARRIAGE-BUILDING.—V.

BY A LONDON COACH-BUILDER.

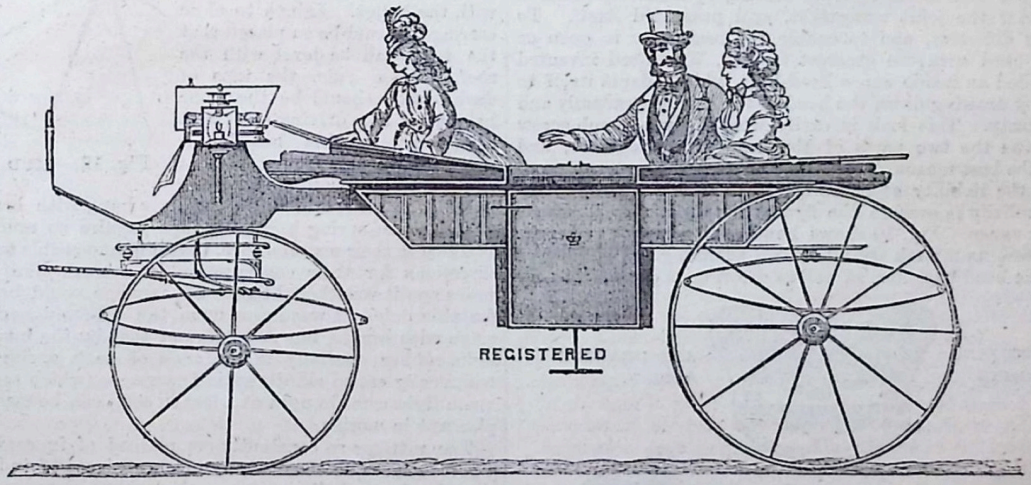
THE LANDAU SOCIABLE.

In giving all the detail of the construction of a carriage, we have chosen the brougham for illustration, this being the national carriage; but our observations would be incomplete if we did not also give some details of the landau sociable, which is becoming more and more popular, and is, in fact, fast assuming the position of the brougham.

This elegant description of carriage is built in two distinct forms, one of which exhibits the latest development of graceful curves and gently flowing sweeps; the other, a series of straight lines and sharp angles. In the illustrations we give of the canoe and the square-shaped landaus it will be seen how entirely different are these two carriages in form, one being constructed according to general principles of taste, the other according to prevailing fashion. Not long ago the canoe-shaped landau was said to present the very lines of beauty, as regards carriage-building, in the highest perfection; to-day the square-shape is spoken of in similar terms. This violent change of opinion cannot very well be pronounced a higher development of taste. The fact appears to be that carriage-building, like the plastic arts, is capable of every variety of form, and so long as that form be expressed according to the laws of harmony, it will convey a pleasing effect to the eye of the beholder.



CANOE-SHAPED LANDAU—OFFORD'S PATENT, REGISTERED.



SQUARE-SHAPED LANDAU—OFFORD'S PATENT, REGISTERED.

It will be unnecessary to say that in constructing this or any other description of carriage, the working drawing is first placed on the canvas in the manner we have described respecting the brougham; but the construction of one is altogether more elaborate than the construction of the other. As the landau is intended to serve as a family carriage, it is necessarily larger than the brougham, and to be made properly should never be constructed to run with less than two horses. It should be very commodious inside, and the front inside seat should be as convenient as the hind one; but as it is intended to serve both as an open and a close carriage, the framework of the body, instead of being carried from the floor to the roof in the solid, is only so constructed half-way up, the whole of the upper part being hinged on to the lower by means of joints specially constructed for the purpose.

These joints are furnished with long arms to which the different parts of the light expanding framework of the head are fixed, and a considerable amount of skill is required to adapt these parts, so that when the entire mechanism of the head is completed it shall present a perfect appearance open or closed.

But what gives this description of carriage a speciality of its own is the many contrivances which have been introduced for lowering or raising the head. The old and simple plan of effecting this, by means of outside joints, came to be regarded by many as not worthy of this mechanical age, the objection to it being that if the head were required to be raised or lowered whilst the carriage was on the road, it was necessary that the coachman should get down from his seat and leave his horses for the purpose, and that if the horses were restive or high-spirited, an accident under such circumstances might easily occur. It was highly desirable that such a possibility should be avoided if practicable, and a deal of ingenuity has since been expended on the subject; but to give a detailed account of the many different contrivances that have been introduced of late years would occupy far more space than could be devoted to the subject in these pages, and it would be invidious for any one connected with the trade to pronounce upon the merits of either. For many years past, inventive genius in the carriage trade has been directed to this particular subject; invention after invention has been introduced, and, to do the inventors but scant justice, they each have a rooted conviction that their own contrivance is the best.

For a long time the object aimed at was simply to enable the coachman to raise or lower the head without dismounting from his seat, and by the adjustment of a series of levers or pulleys and cog-wheels, which were acted upon by means of a winch fixed at the side of the driver, this object was accomplished in two or three different ways. But, not satisfied with this, other inventors sought after a means of obtaining automatic action, such as should enable the riders themselves to open or close the head with the greatest facility, quite independently of their servant. Such an object could only be obtained by means of

springs, but the extreme difficulty of so adjusting them as to ensure uniform action presented a difficulty not easy to overcome; but when inventive genius is once thoroughly awakened, and set on the right track, it is astonishing with what indifference it treats so-called impossibilities. Spring action has been accomplished in a variety of ways, and appears so far

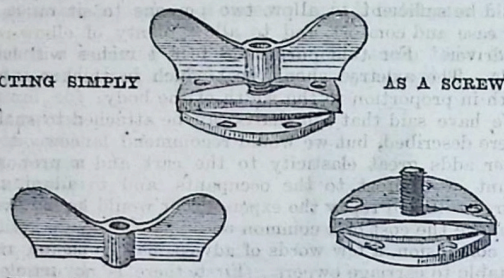


Fig. 10.—PATENT INSIDE LANDAU HEAD-LOCK (1).

successful that it is now being largely adopted, and in our illustrations the extreme facility with which this is effected will be readily seen, the slightest touch from the hand of a lady being sufficient for raising or lowering the head. The drawing showing this has been kindly supplied to us by Mr. Joseph Offord, who, perhaps it will be needless to say, applies this action to landaus of his build; it is necessary, however, to say that by a very neat and simple contrivance of his own, this automatic action of landau-heads is rendered still more effective than it otherwise would be.

When the two divisions of the head are thrown up it is necessary that they should be held together. The old plan of effecting this was by means of what are technically called outside head-locks, which were placed at the point of meeting across the roof. These were not only unsightly, but difficult to get at, and for greater convenience inside head-locks were subsequently substituted; but the difficulty of drawing the two halves of the head to their proper bearing by means of these, so as to render the joint watertight, still presented itself. To avert this difficulty, and to enable the occupants to open or close the head with the greatest facility, Mr. Offord invented and patented an inside screw head-lock, which adapts itself to its work by drawing down the head of the vehicle gradually and with certainty. This lock is easily worked by a thumb-screw which draws the two parts of the head firmly together, and presents the best means of securing against the penetration of wet, and the liability of becoming loose with wear. The extreme simplicity is seen in the figures here given to illustrate this contrivance. Fig. 10 shows how it acts simply as a screw. Fig. 11 presents it with the additional advantage of binding or holding the head together, as well as drawing it down. It may

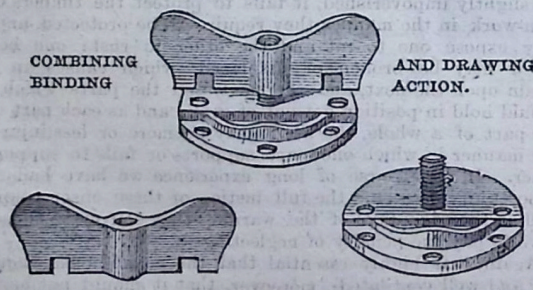


Fig. 11.—PATENT INSIDE LANDAU HEAD-LOCK (2).

be useful to the trade to know that this patent invention is supplied by Messrs. Lowe and Sleigh, of Birmingham.

The landau in its most improved form combines more than the advantages of three distinct vehicles—a close carriage, a barouche or half-headed carriage, and one entirely open. We say it is more useful than the three separate carriages, and for many reasons. It takes up only the room of one—a most important point in town, where space is limited; it costs but little more than one; but the greatest advantage of all is that you have an equivalent to the three *wherever* you happen to be—a matter of no small moment in our constantly changing climate.

Great care and skill are needed in constructing the heads, in order that they may fall flat and level with the elbows, instead of standing up obliquely, about level with the heads of the riders.

Heads of landaus, if made on the old-fashioned principle with outside joints, must have the hoop-sticks and hinges made very strong, as the coachman invariably opens or closes them from one side only, thus throwing a great strain upon the opposite side, which requires to be very strong to prevent a fracture. This danger is obviated by the self-acting heads, as the springs act upon all parts equally in all positions. In fact, the sooner the primitive method of long outside joints is dispensed with, the better.

Before terminating our remarks with reference to four-wheeled carriages, there are various items which require to be noticed. In the matter of steps no definite instructions can be given; experience and ordinary intelligence will generally surmount all the difficulties in this direction.

Steps which are opened and closed by the action of the doors have become very general of late years. The one which is worked by means of rods attached to a slide underneath the body, known as "Offord's patent," is in almost universal use. As a rule, for paved towns, the distance from the ground to the step should be about four inches more than the distance from the step to the floor of the carriage. If the vehicle is for use in country places, it is better to let the step be midway between the ground and the floor. The well-known step with a cover attached to the bottom of the door is not a bad contrivance, and what is technically called a "grid-iron step" is the simplest kind of all, but as it has no protection from the dirt it is not a favourite with the ladies. Lamps to close carriages should be so placed that the top shall be level with the roof. As a rule, the tops of dash-boards should be the same height as the driving-seat rail. The most suitable length for poles is nine feet from the front of the splinter-bar to the tip of the pole. The elaborate dress carriages hung with braces upon a C and under-spring perch carriage require so much skill and practice in their manufacture, that it is impossible to give ample directions for their construction in a work like this. Some years ago it was thought that no carriage could be made comfortable unless it was hung upon the old-fashioned perch carriage with braces, but it was found that by the introduction of india-rubber specially in the ends of each spring, what are technically called elliptic spring carriages (which are, of course, much lighter in draught and less in cost) can be made extremely pleasant in motion.

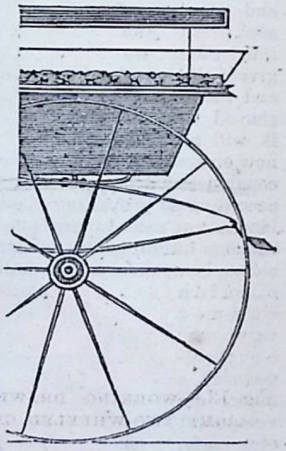


Fig. 12.—MUD SCRAPER.

The rattling so constantly complained of in carriages can in a great degree be obviated, by placing pieces of india-rubber so that the doors shall press upon them when closed. It is a good thing also to have india-rubber at the bottom of the doors for the windows to drop upon when let down.

The difficulty of protecting carriages from the dirt has been recently met by placing what is called a "mud scraper" just at the back of the hind wheels. It is formed of a piece of india-rubber about three inches square and a quarter of an inch thick, held in position by a short iron rod attached to the end of the hind spring, as shown in Fig. 12. An extra amount of india-rubber can be applied, to make a carriage suitable for invalids, by means of "Offord's patent blocks" placed on the top of the springs.

There are, of course, many kinds of carriages not described in these articles; indeed, their name is legion, and it would take volumes to give an account of them; to do so would neither be interesting nor instructive; but no gentleman's establishment would be considered complete without a vehicle of some sort.

The significance of a carriage is indeed great. To set it up

or put it down means sounding a challenge or beating a retreat in society. Who shall ever know the strivings of some to get at this distinction, or the agony of others at being compelled to abandon it? A carriage confers a sort of title. Who has not heard of certain among his neighbours as "quite carriage people," or the definition of respectability as "keeping a gig," or more cleverly, "I guessed what would happen when I saw that stylish turn-out at the door?" With prudent people the sure sign of substantial success is sending a cheque to the coachmaker. It is then certain that Cinderella's pumpkin has at last been changed into the longed-for carriage and pair, or it may only be the useful two-wheeler; and it may be worth while, before closing these papers, to say something on carts, of which there are very many varieties. We must therefore make some selection, and we think we cannot do better than choose that description of cart most generally sought after, and which recommends itself both for purposes of pleasure and profit.

We know of no other description which so effectually fulfils these requisites as the one we here illustrate. It is light in form, pleasing in style, capacious in its internal arrangements; very well adapted for speed, will do well for railway work, carry plenty of luggage, and is equally available for sporting purposes; in fact, it may be recommended for either business or pleasure as a very useful and creditable turn-out.

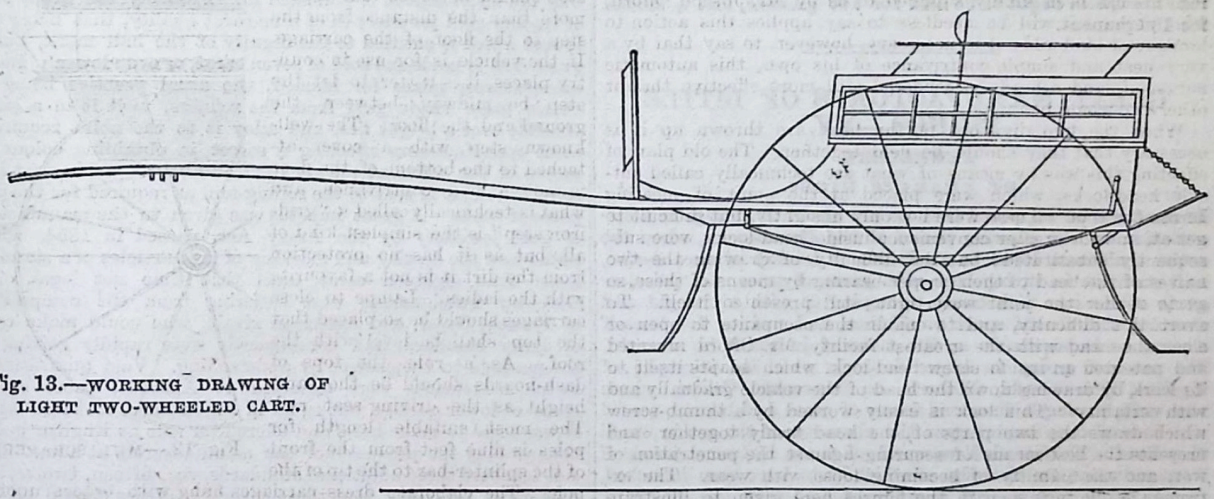


Fig. 13.—WORKING DRAWING OF LIGHT TWO-WHEELED CART.

The make and finish of such a cart may be according to the requirements for which it is intended to adapt it; if, for instance, it is only wanted for rough work, the shafts need only be of ash, the dash and wings may be of wood, a common axle will serve in place of a patent one, and such accessories as lining can be dispensed with altogether. Both the body and wheels may be made with a view rather to strength than beauty, and the process of painting need not be so elaborate as that we have described as essential for the brougham. But such a description of cart is at all times better adapted for a high wheel than a low one, and is therefore more suitable to a horse sixteen hands high than for one of smaller breed: we should recommend, therefore, that such a cart should be made full size, with a wheel 4 feet 8 inches high. Some people have a fancy for wheels even higher than this, but, as a rule, excesses should always be avoided, and we know not where this rule should be observed more strictly than in carriage-building, whether it relates to two or to four-wheeled vehicles.

If an amateur with some mechanical genius wished to try his hand at carriage-building, he might easily construct such a vehicle as this himself; the body is simple in form, and easily framed together; the manner of fitting the shafts and springs is well denoted in the drawing (Fig. 13), and all the necessary fittings can be purchased ready to hand.

For his special benefit we will here furnish a few necessary particulars. The body should be framed of sound ash, the part above the seat-line being made open, with an iron rail running up the front, along the top, and down at the back end of the body. The length of the body at bottom should be 5 feet 2 inches, and the depth of boot-side 14 inches; height of rail framework above boot 9 inches, length of shaft from front of dash to point 6 feet 2 inches, and width of shafts between points 23 inches. The seats should be made to shift, so as to adapt the cart for two or four passengers, and the width of seat-room should be sufficient to allow two persons to sit on each seat with ease and comfort, and to allow plenty of elbow-room for the driver. For this purpose 3 feet 4 inches will be found ample. The axletree should be $1\frac{3}{8}$ inch in thickness, and the length in proportion to the width of the body.

We have said that ash shafts can be attached to such a cart as here described, but we would recommend lancewood, as this timber adds great elasticity to the cart, and a proportionate amount of comfort to the occupants, and to adopt a patent axletree will well repay the expense that would be involved over and above the cost of a common one.

In conclusion, a few words of advice may be useful, and even profitable to carriage owners. First, there is no article which justifies the proverb, "A stitch in time," so well as this; and we would say to a friend, "Always keep your carriage in good repair." It is a luxury necessarily of so costly a nature, that it is exceedingly desirable to keep down the expense of maintenance as much as possible, and this cannot be done better than by avoiding general repairs, and the way this may be done is by having the vehicle periodically overhauled. If the paint be slightly impoverished, it fails to protect the timbers or the iron-work in the manner they require to be protected, and wet may expose one to rot and the other to rust; one bolt or screw may be broken or displaced, which causes an extra strain upon the next, and the next, and the parts which they should hold in position get out of gear; and as each part is but the part of a whole, the whole may be more or less injured by the manner in which one part supports or fails to support the other. In the course of long experience we have had ample opportunity of seeing the full justice of these observations, as well as the advantage of the warning they convey to those who have to pay the penalty of neglecting it.

Again, it is highly essential that the coach-house should be dry and well ventilated; moreover, that it should not be in too close propinquity to the stable, or anywhere near a manure heap, for the ammonia rising in steam from one or the other is highly destructive to varnish, as many have found to their cost. When a carriage is in regular use it should always be washed after it is done with, before being returned to the coach-house, and for this purpose a plentiful supply of clear water is essential, together with a good soft sponge and chamois leather. In bad weather, when a carriage gets covered with mud, if care be not taken in removing it, the panels will be scratched, and by a continuance of carelessness on the part of the coachman, the looking-glass surface destroyed. Such a thing as a spoke-brush should never be allowed inside the coach-house of any

one who has any regard for his carriages; it encourages idleness in the coachman, and will soon show the injurious effects of its use on all the timbers and wheels.

When a carriage is not in regular use, but left standing in the coach-house, as it will be sometimes for weeks, perhaps months together, it is a mistake to suppose it does not require attention. By neglect under such circumstances it may sustain more damage than if in daily use, only that the damage will be of a different kind. By being closed up, moth will get into the cloth of the lining; and by not being washed the timbers will shrink and the joints separate; for it must be borne in mind that, however well seasoned timber may be, the absolute absence of all moisture in it would simply mean dry rot. The carriage should therefore occasionally be drawn out, and well aired, and washed. If these hints be well and carefully attended to, the best economy will be effected, the owner will get the largest possible amount of return for his outlay, and his coach-builder need never get into discredit.

We conclude with a word to young British coach-makers on the subject of charges. Somehow the trade has got a very ugly character on this head, and we fear there is some ground for the complaint which is so common. By all means determine to produce the best possible article, but go in for a large business at small profits, and aid the country in securing in the world the best character for cheap and good carriages. A first-rate brougham ought to be sold for 140 guineas, and a landau for 180 guineas.

GREAT MANUFACTURES OF LITTLE THINGS.—XV.

JEWELLERY.

BY CHARLES HIBBS.

It must not be supposed that we are about to indulge in a dissertation on the glowing period of the Renaissance, when the artist craftsman loved to dwell over a trinket of rare device, and enshrine in it, together with gems of price, the priceless gems of his own rich fancy, stamping it with a thought and meaning that should speak to all time, and making for himself a name as imperishable as the material in which he wrought. We are not going to linger lovingly over the triumphs of Ugolino, Brunelleschi, Ghiberti, or Benvenuto Cellini, whose rare skill, tracing a thousand forms of grace and beauty, traced also lines of deep import upon the character of the age in which they lived. Neither shall we speak of those historical jewels of fabulous value, for the sake of which fleets have been launched, armies set in motion, and kingdoms tossed from one master to another. The romance of human pride and passion, in many chapters, for which the bit of shining carbon or the spoil of the homely oyster has furnished the theme, must have no charms for us; nor must we be tempted into the mazes of antiquity by the allurements of a search after the origin of one of the most ancient of all arts. Could we dare to dwell upon the subject, it would, indeed, be found to be a fertile one, and we should perhaps be astonished, if not humiliated, to find how much influence "barbaric pearl and gold" has had upon man's history from the beginning. Ever the symbol of splendour and power, the unconscious stone itself has aided in enslaving humanity; for magical properties have been assigned to it, and it has become the object of superstitious reverence and regard.

To descend into the plainest matter of fact, we have to deal with jewellery as a *manufacture*, giving employment to many thousands of hands, and using up many tons of material. The latest statistics give about 12,000 as the number employed in Birmingham alone, directly or indirectly, by this flourishing industry. Of course a large part of the vast production is for export, and equally of course, not much of it is composed of the true precious metals that formed the staple of the *orfévrerie* of the Middle Ages. A good deal of it is honest brass, dignified sometimes with more high-sounding names, and technically known in the trade as "compo." A thin wash of gold, deposited by the electro process, lifts it a step higher in the commercial scale, and a still higher position is gained by plating it in the ingot by the older method. The highest, or true aristocratic pinnacle, is held by what is termed "solid," or gold jewellery of the better qualities. It will be convenient to adopt this classification in the few preliminary remarks we have to make about the materials used in the manufacture.

Gold jewellery, as its name imports, is that in which the purest and most imperishable of all metals forms the substance. It must not be supposed, however, that it is always identical with that costly medium which passes current among civilised nations as the measure of value, or that its name is always a guarantee for its metallic nobility. The orders of jewellery-work, like those of society, have infinite gradations, and run into each other in a manner which makes it difficult to draw the line. Thus, the lowest quality of gold work may be vastly inferior to the highest quality of plated; and that, in its turn, may be degraded below the highest level of the plebeian "compo." Standard gold, which implies the quality used for coinage, and which indicates the nearest approach to purity at which the metal can be worked, or made to stand wear and tear, is pretty generally known to be what is called twenty-two carat; *i.e.*, two parts of alloy in twenty-four; that number of carats being contained in an ounce. For the very best kinds of jewellery, no higher quality than eighteen carat is used; and for the many qualities below the highest, the proportion of gold to alloy may shade off into an inappreciable quantity. Some jewellery which is *called* gold has so little of it in its composition that the "aqua" test will fail to detect its presence, and it is difficult to imagine why the make-believe is persisted in. Probably the great bulk of trading gold jewellery is of nine-carat quality, that being the lowest which is entitled to the dignity of the hall mark, but a great deal is made and sold of seven carat, or even lower. Every manufacturer mixes for himself, the usual practice being to obtain grain virgin gold from the refiners, melt it in a small crucible over a bright fire, and alloy it to the point required; some manufacturers affecting a secret in obtaining colour by means of the different metals used as alloys. When cast into small ingots, it is sent to the rolling-mill as required for the purposes of trade. A great impetus was given to the manufacture of gold jewellery by the Assay Act, passed in 1854, which authorised the testing and marking of gold articles of a standard lower than eighteen carat, until that time not legal. The Coventry watchmakers were suffering from the competition of French, Swiss, and American rivals, who could make cases of lower standard, and consequently were rapidly getting all the markets to themselves by underselling. Vast quantities of watch movements were exported to America, there set in cases of lower quality, but equal in appearance, to those which it was legal to make here, and offered for sale as English goods, thus ruining the prospects of the manufacturers at home. The Act legalised three additional standards, viz., fifteen, twelve, and nine carat, providing that these several qualities should be distinctly indicated by marks, so as to protect the purchaser. But the mark itself was everything, and the jewellers, who had been hitherto working in all sorts of standards with no restriction but their own honesty and the sharpness of their customers, gladly seized the opportunity of getting the stamp of genuineness upon their goods. The trade rapidly went up, and in the space of ten years the quantity of gold articles passing through the Midland Assay office rose from 4,000 to 30,000 ounces per annum.

Of late years, a variety of gold jewellery, called *coloured*, has come into fashion. It is of a rich deep yellow, and the surface is slightly frosted; in fact, it is to plain gold what dipped and lacquered brass is to the original article. On account of the gorgeous appearance it presents, it commands great favour in the market, especially as the notion is pretty prevalent that coloured gold must necessarily be pure, or at least of very good quality. Popular opinion is right for once, and, singularly enough, both of these alternatives are true. The quality must be good to begin with, and the surface which meets the eye is perfectly pure. The process of producing what is called *colour* is very simple, and is nearly identical with that of "dead dipping" in brass work. The articles when finished are immersed in a bath of muriatic acid, which eats away the alloy, and leaves a thin crust of genuine gold, very finely granulated in texture, and its natural colour heightened by the disposition of its particles. If the quality were too low, the larger quantity of base metal or alloy, that would be eaten away by the acid, would leave the gold in a honeycombed state, besides destroying the structure of the work; no gold is therefore subjected to this

process that is not at least fifteen-carat standard. A sharp line of division has been created in the trade by the introduction of this method, and the manufacturers of coloured jewellery are considered to follow a distinct branch, higher than that followed by the makers of plain gold work, which may be of any standard, down to none at all.

Plated jewellery comes next in rank, though, as we have intimated, it frequently exceeds in costliness its more pretentious rival. Its peculiarity consists in the fact that the metal is coated or veneered with gold before it is worked up, so that in all the subsequent processes the art of the jeweller is directed to keeping the plated surface outward, and uninjured. The body of the metal is copper, moderately alloyed with brass, or it may be said to be brass of more than average quality. This is cast into bars of convenient size, and the plating is effected in the following way:—A piece about 5in. long is cut off, and the top surface planed, filed, and scraped, to a dead level; it is also pickled, to cleanse it from impurities. A thin plate of gold, also levelled and made perfectly clean, is placed on the top, and the two flat surfaces are bedded together with immense pressure. It was the custom formerly to lay a heavy block of iron, called a "bedder," on the two metals, and strike upon it with sledge-hammers until it was supposed that the contact was complete; but it is usual now to employ a powerful press for the purpose, of the same kind as those used for striking large medals. The machine is not driven in the ordinary way, by two arms, but their place is supplied by a horizontal wheel five or six feet in diameter, of great weight, and loaded also at several points of its circumference with solid iron balls. The upper die, or hammer-block, is raised as far as it will go, and the two plates to be bedded are placed on the smooth anvil below. Impetus is given to the wheel, and it spins round upon the well-oiled screw, gathering momentum as it rotates, until the block comes down with a tremendous thud upon the plates, bedding them at a blow. They are then taken away, and bound tightly together with wire, when the edges are plastered lightly with a solution of borax, and small pieces of "panel" solder are placed here and there, adhering by the moisture. The whole is then placed in a "muffle," or blazing oven, and heated to a dull red, when the solder flashes in between the two plates, and cements them together. Thereafter they can be rolled, drawn, hammered, stamped, spun, or otherwise attenuated to any extent, and the gold will still follow the fortunes of the baser metal, stretching as it stretches, bending as it bends, yielding as it yields to every force impressed upon it, and still preserving faithfully the same proportion of relative thickness, whatever shape it may assume. That thickness is, of course, determined by the quality of the work intended to be made. The gold may be of good honest thickness at last, calculated to stand a good deal of rubbing and hard usage before it is all worn away, or its tenuity may be so extreme that it will scarcely bear touching: but the appearance of the work when finished will be so nearly equal as to deceive any but an expert. Practically, the extent to which the plating can be reduced is limited by the possibility of working it up without injury. One uniform quality is now almost invariably used by jewellers, the fixed price of which, in sheet, is one shilling per ounce; a few years ago the common price was 26s. or 28s., which shows the immense progress that has been effected in the art of making things appear that which they are not. For the present quality, the relative thickness of the two metals would be perhaps in the proportion of 1 to 40.

Gilt jewellery differs from the above in this, that the gilding is done after the article is finished, by the process of electro deposition. It may be that better style is obtainable by this means, the artificer not having before his eyes the fear of injuring the thin gold plate at every step of his operations; and for the same reason, the designer would have more freedom of fancy. The invention of voltaic deposition, it is well known, created a new era for the manufacture of silver-plated wares in this respect; rendering possible the introduction of foliated ornament and the human figure, together with a vast range of intricate design that was beyond the reach of the old method. The superimposed ornamentation, or "mounting," as it was termed, of the old-fashioned plated work, if at all freely designed, was of necessity cast in the solid sterling metal, thereby greatly adding to the cost; and in many points of construction, the maker was restricted by the material he had to deal with. When, however, he found that the new and beautiful discovery which science had made for him would enable him to overlay with the precious metals any fantastic shape he might be able to produce, and that after every detail of its ornamentation was complete, he gave the reins to his fancy, used *all* the resources of the metallurgical arts to obtain form, and succeeded in producing things of beauty, such as the art, with all its ancient glories, had never produced before. It is impossible but that the same causes would affect the manufacture of jewellery, though perhaps in a somewhat less visible degree. The jeweller would be able to use cast or sculptured ornaments upon different parts of his work; he could engrave it deeply, or file it into shape; he could manipulate it at his will; and he could be sure of getting on every part of it at least an even coating of pure gold. But as some alloy enters into the best of metals, so there was an ingredient of evil in this beneficent discovery. There was positively *no* limit to the thinness with which the gold could be overlaid; and so the cupidity of the jeweller was tempted to palm off articles upon the public as honestly gilt, when the merest possible wash existed on the surface. This has brought *gilt* jewellery into disrepute, and given it a rank below that of *plated*, when, in the nature of things, those relative positions should have been reversed.

Compo jewellery is simply the same as the last, with the gilding left out. The makers of this variety aim at getting such a mixture of metals as will look well when finished bright; and some profess to have a secret in obtaining colour; whether well founded or not, the professional buyers are, no doubt, well able to judge. Of this material are made the cheap brooches, earrings, pins, lockets, and other trinkets which are sold by the voluble cheap jack at the country fair, and which, to the eyes of his admiring audience, look equal to the crown jewels at least. A flaming shawl brooch might in this way be retailed for a shilling, which possibly cost the vendor sixpence, and was originally produced for a fraction above a penny! The cheapness of these articles is something marvellous. A few years ago, a trinket called the "book locket" had a great run. It was in the shape of a volume, with hinges and clasp, and the sides or covers of the book marked with an incised ornament of good pattern. Inside were portraits of the Prince and Princess of Wales, fairly executed, and the price, wholesale, was about one halfpenny each! So long as no fraud is practised upon the purchaser, there is no reason why we should deprecate the use of these common and simple articles of personal adornment: the passion is universal; and a fondness for ornament, if bestowed upon objects which have form alone to recommend them, is at least as commendable as the vulgar desire to appear with the wealth of an empire upon the person.

Besides metal, the jeweller's stock in trade consists of precious stones. Of these the name is legion, and the degrees of value almost infinite. The diamond, king of gems, stands at the head of the list, and beneath him are ranged the other colourless transparent stones, such as the chrysolite, the aquamarine, and various other crystals. We have spoken of them as colourless, but the diamond has sometimes a tint, and is valuable therefore. The rule is, that a perfectly white diamond, and one which has a decided uniform tint, are about equal in value, weight for weight; but a diamond partially tinted, or whose tints are clouded and uncertain, is vastly inferior. There is some difference between the Koh-i-noor and a diamond that can be sold for a shilling, yet such is an ordinary price for very small stones of perfect cut. Indeed, some exceedingly small diamonds (used for clusters, or diamond frost) are sold by weight, and have singly no appreciable value. Following the "white and bright" stones, as the trade term goes, are the coloured transparent gems, such as the ruby, the carbuncle, the garnet, the amethyst, the emerald, etc.; and after them the opaque, white and coloured, such as the opal, the sardonyx, the agate, the onyx, the blood-stone, and the turquoise. A great many others might be enumerated; and all are, as it were, heads of families which comprise innumerable varieties. All these are cut or otherwise shaped by the art of the lapidary; some in facets, to enhance the brilliancy, and some, as the turquoise, in bulbous or globular form. No precious substance set by the jeweller in his work is used without shaping by the hand of man, except the two beautiful productions of marine artificers, viz., pearl and coral. Few of the cut stones are either found or worked in England, but are imported, literally by the bushel, from different parts of the Continent. Of

these the cheapest is the sardonyx, and consequently it is the most used. But there are also vast quantities of imitation gems, as closely resembling the originals as the gilt or plated setting resembles pure gold, which, it may easily be conjectured, are used in the same proportion as the false usually bears to the true in other concerns of life besides the manufacture of jewellery. The garnet is the stone most closely and generally imitated, and may be bought, the size of a small bean, regularly cut into facets, for as low as threepence per dozen. France is clever at producing these shams, and a perfect thing called the philosopher's stone, which is not an imitation of anything particular, but has a very beautiful and gem-like appearance, is imported from there in large quantities.

It is estimated that the consumption of gold and silver in the jewellery and cognate trades in Birmingham cannot be less, yearly, than £1,000,000 worth. Stones and their imitations would perhaps absorb a quarter of a million more; so that the trade has not lost its ancient reputation for wealth, acquired in the days when the goldsmiths and jewel-dealers were the bankers of the world. It is by no means an uncommon thing for a large manufacturer to melt down 1,000 ounces of gold bullion at one time; though the rule is, of course, to melt much smaller quantities, down to the fusion of an ounce or two over the kitchen fire. No trade has furnished so many examples of wealthy manufacturers having risen from the ranks; and among the well-appointed factories (some with real architectural pretensions) of the clean and respectable "jewellers' quarter" in Birmingham there are few concerns which could not be pointed at as having had their origin in the "garret." As remarked by Mr. J. S. Wright: "All that is needed for a workman to start with as a master is a peculiarly-shaped bench and a leather apron, one or two pounds' worth of tools (including a blow-pipe); for material, a few sovereigns, and some ounces of copper and zinc. His shop may be the top room of his house, or a small building over the washhouse, at a rent of 2s. or 2s. 6d. per week, and the indispensable gas jet, which the Gas Company will supply on credit. With these appliances, and a skilful hand, he may produce scarf-pins, studs, links, rings, lockets, etc. etc., for all of which he will find a ready market on the Saturday among the numerous 'factors,' whose special business it is to supply the shopkeepers throughout the country."

Having now treated of jewellery *material*, we shall next describe the methods of manufacture.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XLV.—BARON BORN, F.R.S.

BY JAMES GRANT.

This Bohemian noble, who was one of the most skilful metallurgists of his time, and who, while living, became a martyr to science, was a native of Carlsburg, a royal town and fortress in Transylvania, a place once called Weissenburg, and sometimes Belgrad. His birth occurred some time in 1742. His family was noble, and early in life he was sent to Vienna to study under the Jesuits, who perceiving in the youth more than common abilities, and believing that one day he would prove an honour to their order, prevailed upon him to enter it; but of their society he was only a member, as a novice, for eighteen months.

Leaving Vienna, he went to Prague, where he engaged in the studies of mining and natural history, and the branches connected with them; and in 1770 he was received into the Department of the Mines and Mint at Prague.

From his letters (says Townson, in his "Travels in Hungary") we learn that in the same year he made a tour, and visited the principal mines in Hungary and Transylvania, during which he kept up a correspondence with the celebrated Ferber, who in 1774 published it in his letters. It was during this tour that the baron, then in his thirty-second year, so nearly lost his life, and when he was struck with that disease which embittered the rest of his days, and which a philosophic mind and active disposition alone rendered supportable.

It was at Felso-Banya, a small town of Hungary, in the palatinate of Tathar, where gold mines have been wrought from time immemorial, that he met with his misfortune, as he mentions in his eighteenth letter to Ferber.

There he had descended into a mine, where fire was used as a means for detaching the ore. Of this process he wished to observe the efficacy too soon after the extinction of the fire, and while the mine was full of the noxious and chiefly arsenical vapours raised by the subterranean heat.

"My long silence," he wrote to his friend Ferber, "is in consequence of an unfortunate accident which had nearly cost me my life. I descended the great mine to see the manner of applying the fire, and the effect of the latter on the ore; but the fire was scarcely extinct, and the mine was full of smoke!"

How greatly he suffered in his health from this accident may be inferred from the circumstance that he could hardly bear the motion of his carriage. His friend and correspondent was John James Ferber, the eminent Swedish mineralogist, who, though destined for the profession of medicine under the celebrated mineralogist Von Schwaab, became famous as a metallurgist, and was afterwards Professor of Natural History and Experimental Philosophy in the High School of Mittau, and who, when he closed his life at Berne, in Switzerland, was buried by the side of the illustrious Haller.

Born, after his accident, hastened to Vienna, where he received the appointment of Councillor of Mines at Prague. In 1771 he published a small work of the Jesuit Poda on the various kinds of machinery used in and about mines, and in the following year appeared his "Lythophylacium Borneanum."

The latter was the title of the catalogue of his collection of fossils, which he afterwards disposed of to the Hon. Mr. Greville. By this publication he won the attention of mineralogists, and was drawn into a learned correspondence with the first men of his time. He was now made a member of the Royal Societies of Vienna, of Stockholm, and Padua, and, in 1774, of that of London.

While resident in his native country, Bohemia, he did not apply himself to minerals alone, for the activity of his mind induced him to seek for other opportunities of extending his knowledge and being useful to the world. He took an energetic part in the preparation of a work entitled "Portraits of the Learned Men and Artists of Bohemia and Moravia," and was also concerned in the editorship of the "Acta Literaria Bohemiæ et Moraviæ."

Prague and Vienna were both without a public cabinet for the use of students; and there, at his request, the Government was induced to form one, which he materially assisted by his labours and contributions; and at Prague, in the year 1775, he laid the foundation of a literary society, which issued several volumes under the title of "Memoirs of a Private Society in Bohemia."

The Empress-Queen, Maria Theresa, having now heard his fame, invited him to Vienna in 1776, to arrange and catalogue the Imperial collection; and in 1779 he published his splendid work on conchology, the Empress defraying, from her private purse, the expense of a great many copies; but on her death it was discontinued, her successor, the Emperor Joseph, proving less a patron to science and literature, and caring nothing about the undertaking. Born had, however, the honour of instructing in natural history the Archduchess Maria Anna, who was very partial to that branch of study, and whose museum he arranged and catalogued. In 1779 he was raised to the post of Actual Counsellor of the Court Chamber, in the Department of Mines and Mint, an office which detained him constantly in or about Vienna.

But now the consequences of his accident in the gold mine of Felso-Banya began to recur in the most severe manner; he was attacked with excruciating spasms in the bowels, and these rose to such a degree as to threaten a speedy termination to his life. In this extremity he had recourse largely to opium. A considerable quantity of this was placed near him, with directions that it was to be taken in small doses; but once, being desperate, through the intensity of his pain, he swallowed a large draught, which brought on a lethargy that lasted for twenty-four hours.

When sense returned he was free from pain; but this mysterious disorder now attacked his legs and feet, more particularly the right leg, in which he became lame for the rest of his life. This lameness was sometimes accompanied by pain; and now his feet began by degrees to shrivel and to wither up, so that he was compelled to sit, to lie, or recline upon a sofa;

but he could never again move from room to room without assistance. Notwithstanding this terrible fate, the freedom and activity of his genius induced him to take a deep interest in all the events of his time, and to be active in all those institutions which were slowly being developed for the reformation of mankind. With this object, he became initiated in freemasonry, an order which, under the late Empress-Queen, was obliged to keep itself very secret in Austria, but which Joseph, on ascending the throne, was somewhat inclined to tolerate and even to foster. Hence, the baron ventured to found in the Austrian capital a lodge called the "True Concord," which, though strictly masonic, was nevertheless a society of learned men, whose lodge, after it was opened, became a place of rendezvous for the literati of the metropolis. "No doubt," says Townson, "the obstacles these gentlemen would find to the progress of science and useful knowledge in the church hierarchy, and in the cabals of courtiers, would draw their attention to political subjects; and subjects were really discussed there which the Church had forbidden to be spoken of, and which the Government must have wished not to be thought of. At their meetings dissertations on some subject of history, ethics, or moral philosophy, were read by the members; and commonly something on ancient and modern mysteries and secret societies. These were afterwards published in the 'Diary for Freemasons,' for the use of the initiated, but not for public sale."

As all the learned of Vienna belonged to this remarkable lodge, they gave rise to a periodical work entitled "Physicalische Arbeiten der eintrachtigen Freunde in Wien," which was continued from time to time by Born and his brother masons ("Travels in Hungary," 1797). But what raised him highest in public opinion was his knowledge of mineralogy, and his successful experiments in metallurgy, and principally in the process of amalgamation.

The use of quicksilver in extracting the noble metals from their ores was not a discovery of the Baron's, nor of the century in which he lived; yet he extended so far its application in metallurgy as to form a brilliant epoch in this most important art. After many private experiments, and great expense, he became convinced of the utility of his method, and laid an account of his discovery before the Emperor, who gave orders that a decisive experiment should be made on a large quantity of ore at Schemnitz, the mines of which are the most extensive in Hungary, being some five miles square, and of vast depth, the old tunnel for drawing off the water being 1,100 feet below the surface, and the new being lower still.

To witness this, he invited the most celebrated metallurgists and chemists in Europe, and so thither came Ferber, Elhujer, Charpentier, Trebra, Poda the Jesuit, and others, who universally approved of Born's invention.

This approbation proving so general, he published, by order of the Emperor, his "Treatise on the Process of Amalgamation," with many engravings of the requisite machinery and instruments. If his production brought him fame and emolument, it also won him the ill-will and envy of many of his brother metallurgists; and though great cabals were raised against him and the introduction of his method, the advantages of it were so apparent that the Emperor ordered it to be used in all the Hungarian mines, and as a recompense to Born, gave him, for ten years, the third part of the savings from the process, and 4 per cent. of this third part for the next twenty years.

In 1787 a translation by R. E. Raspe of his "Travels in Transylvania and Hungary" appeared in one volume 8vo in London. Though he suffered very much in the latter part of his life, yet this did not prevent him from continuing his literary pursuits. Hence, in 1790, he published his "Catalogue Raisonnée" of Raab's collection of fossils, which had been formed chiefly by his own donations. This work was printed in two beautiful volumes, and he was in progress with his "Fasti Leopoldini" when a mortal malady seized him. "Notwithstanding the varied advice of his physicians, his disease continued. In such a state quacks find easy access to the sick. Who is not then ready to seize the nostrum of the bold pretender? One of these gave him a decoction, which soon calmed his sufferings, and which he was assured would cure him in a few weeks. He continued the use of this for the last five months of his life; it really diminished his pains, but his friends observed that his cheerfulness, which hitherto had not left him, diminished likewise, and that spasms often attacked his upper limbs. On the 21st of July, 1791, he was seized with spasms and cold; the former subsided on friction, but he lost his speech. On the subsequent days he had different attacks till the 28th, when he found himself better; but he was soon again attacked with spasms, and in these he expired."

His house had ever been open to the travelling literati who visited Vienna, and unprotected genius had ever found in Born a sure patron and firm friend. He carried this so far as to impair his estate, and latterly he became insolvent through usurers and money-lenders, to whom he was compelled to have recourse for money to continue his experiments; hence he left a wife and two daughters in poverty. He was of a middle size and delicate constitution, and had a dark complexion, with black hair, and large black eye-brows. Wit, satire, and a quick comprehension were indicated by his eyes, and all his turns of countenance were lively and pleasing.

He died in his forty-ninth year, and as all his life-long ailments were deducible from the accident which occurred in the mine at Felso-Banya, he was not incorrectly termed "a martyr to science."

OPTICAL INSTRUMENTS.—XXV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

LANTERN CONSTRUCTION (*continued*).

We have now to consider the best method of carrying the slide, and the optical parts by which it is illuminated and magnified. These form one optical system wherein it is necessary that all the elements shall be perfectly centered one to another. In the ordinary lanterns the *front*, comprising the fitting that supports the condenser, the stage, and the conical nozzle that carries the power, is made of tin in one piece, as shown in Fig. 104; but if a lantern is to be used for optical demonstrations as well as for showing views, it is requisite that the stage and power should be separable from the condenser. I have therefore arranged the several parts in the following manner, to meet all the practical requirements of both exhibitor and demonstrator, without sacrificing that rigidity of the optical system which is an essential point in its construction, for securing correct centering of condenser and power by the perfect parallelism of the parts into which they each screw:—

The Condenser Mount.—The advantage of using a pair of symmetrical plano-convex lenses for the condenser is that, by carrying a third lens, should either back or front element be broken or injured, it can readily be replaced, if suitable provision be made for this in the brass mount that supports the pair of lenses. In the ordinary way the front lens is burnished permanently into its cell, while the back lens is either burnished into a screw-ring that is removable to allow of the inner surfaces of the lenses being cleaned, or this lens is kept in position by a cap that screws over it on to the outside of the brass cell. I prefer making the cell in the following manner, as it provides, as far as possible, against the lecturer being placed *hors de combat*, and to facilitate repairs should the operator be located in a foreign or out-of-the-way place. The cell, C (Fig. 121), is made of brass tube a size larger than the diameter of the lenses; one end is turned up with a bezel, B, on to which the flat face of either lens is dropped. Over the lens, close inside the cell, a brass ring, R, fits; on to the edge of this ring the back lens is placed curved face downwards; and over all the cap-ring S is screwed, so as to keep all firmly in position. Three or four ⅛-inch air-holes are cut through the outer and inner tubes of the cell, to allow of moisture escaping freely. The condenser mount is turned quite smooth on the outside to allow of its fitting smoothly into

The Flange.—This consists of a tube a size larger than the condenser cell, soldered into a circular or square plate F, which is attached by three counter-sunk screws to the body of the lantern. The inner half of the tube fits a hole cut in the body of the lantern; the outer half is polished and fitted with an upright pin, P, that forms the stop of the bayonet-joint on the stage.

The Stage is usually open only at the sides, being closed above and below, and the frame that carries the slide is held in place by a spring-plate, as shown in Fig. 122 at A and B. All exhibitors must have experienced the inconvenience attendant on the employment of a spring-plate, when an extra thick frame, such

as "the rolling waves effect," has to be pushed into the old-fashioned stage, a matter only to be accomplished by much wriggling of the frame, to overcome the sticking when the stiff springs are jammed home. Again, there are many excellent "effects" which could be introduced to the general public, such as balloon ascents, ascending fairies and descending demons, etc., if the slides could be worked vertically in the same manner as panoramic slides are moved horizontally, but which the solid top and floor of the stage as thus made prevents. To obviate such shortcoming I employ two stout brass plates, pierced with central openings, and frame them together with four brass pillars, P′, and eight spherical-headed screws, N (Figs. 121 and 123), to allow of frames being inserted horizontally in the usual way, as shown at H (Fig. 123), or vertically, as at V; and dispense with the spring-plate altogether, to allow of a standard frame being simply pushed in without impediment, so as to rest upon the lower pillars, in which position it will stand upright, or can be prevented from falling forward by means of a quick-action screw guarded by a button, which works through the front stage-plate, as shown at C″ (Figs. 121, 123). This clamp-screw is very convenient, as it can be turned back rapidly to allow of the insertion of a frame of any thickness the opening between the plates of the stage will admit of; or it will firmly clamp any mechanical frame, and leave both hands of the exhibitor free to work it, thus providing great freedom of action for any effect that can be devised. To ensure the slide being centered with the optical system, a small brass arm, bent out at a right angle, works stiffly on a pivot screwed in the stage-plate, on the side opposite to that on which the frame is inserted, as shown at S (Fig. 123), so that it can be turned up to stop the passage of any frame of a standard size, when central with the axis of the optical system, or down out of the way, as indicated by the arrow, if the frame is panoramic or of unusual length. To the back of the stage-plate is attached a "counter-flange ring," C′ (Fig. 121), which is one size larger than the outside of the tube of the flange F, whereon it fits, and is fixed in position by a bayonet-joint, J, to ensure the sides of the stage-plate standing truly parallel with the sides of the lantern body. To the front stage-plate is attached the large tube T, within which slides another tube T′, not only for the purpose of providing a certain amount of adjustment when lenses of different focal length are employed, but to provide for the quick interchange of certain accessory apparatus and demonstrating appliances. The end of the inner tube is fitted with a female screw-ring, A, into which the *jacket*, J, of the power screws, or the "lengthening tube," L, when a lens of long focus is to be employed.

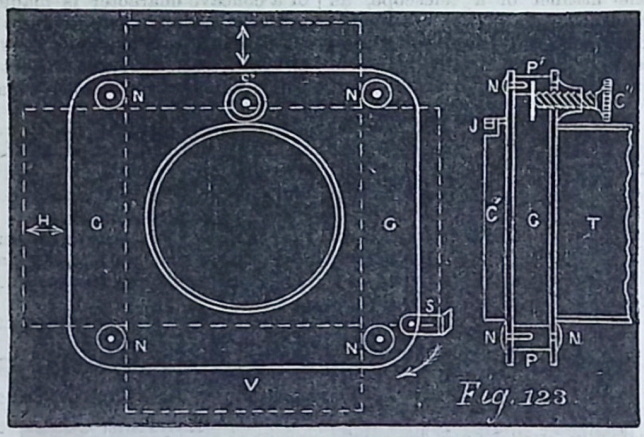


Fig. 123

The *standard frame*, for pictures 3 inches in diameter, is 7 inches long by 4½ wide, and ⅜-inch thick. It should be made of mahogany, not cedar, as that gives off a resinous vapour (when the weather is hot or the frames have been warmed by use in the lantern) which condenses on the cold glass slides in hard drops that are very troublesome to get off. According to the old style the pictures were painted on glass discs, which were dropped into counter-sunk cells turned in solid blocks of wood, and kept in place by a coil of spring wire. This plan is very objectionable, as the design is apt to turn round in its cell, and of course appears askew on the screen. The modern method, introduced with the photographic system of producing slides, ensures the design being central and standing true on the screen, as they are in the first instance photographed in accurate adjustment on glasses 3½ inches square. Such designs are protected by double glasses between which an ornamental paper mount is inserted to "stop out" all parts not included within the 3-inch disc, the edges of the two squares of glass being bound together by strips of dark purple paper. Such slides are fitted into grooved frames of the size given above, three sides of which are tongued and glued together, the fourth side being left free to allow of the insertion of the 3-inch square slides. When in place the whole forms a solid block with the design perfectly centered. I run a bead along one long edge of the frame, so that the exhibitor may know that when the bead is uppermost and towards his breast, then *the slide* is in a doubly-reversed position in the frame, and in the right position for being inserted in the stage, to secure the image on the screen appearing as it should do, especially if there should be any inscription on it. The paper *stop-mount* should be printed in black, with a white design from a wood-cut around a 3-inch circle, within which a square, measuring 3 inches across its diagonal, is laid down. A design should provide for two scrolls whereon could be inscribed *the nature of the series*, such as "Science," "Geography," "History," "Hogarth," etc.; *the name of the subject*, such as "Solar Spectrum," "Map of the World," "Falls of Niagara," "Finis," and two shields *for the number of the series*, and the monogram or trade-mark of the publisher. Instead of a paper stop-mount, such a design may be transferred to the covering glass in black and gold, which pre-

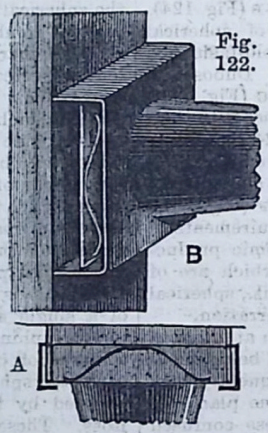


Fig. 122.

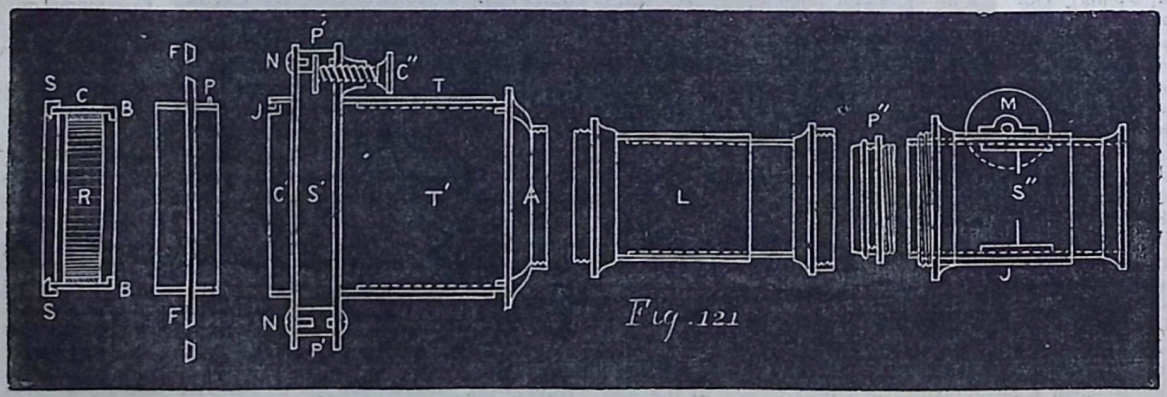


Fig. 121

sents a remarkably handsome appearance to the slide, at but little cost to the producer. The stop-mount, whether made of paper or printed on glass, must for some subjects be of square design 3 inches at the sides.

The *lengthening tube* is simply two pieces of tube, fitting one inside the other, after the manner of a telescope, as shown in L (Fig. 121), one piece being furnished with a male screw that turns into the front tube, T′, and the other with a female screw that receives the jacket, J, of the power. This is only used when a lens of long focus is required. If the focal length is very great, it is better to give support to the front by placing a wooden crutch under this tube.

The *power*, or "objective," P″ (Fig. 121), is the magnifying element of the optical system, and should be so constructed as to be free from spherical and chromatic aberrations, that the picture may appear clearly defined over the entire surface of the disc on the screen.

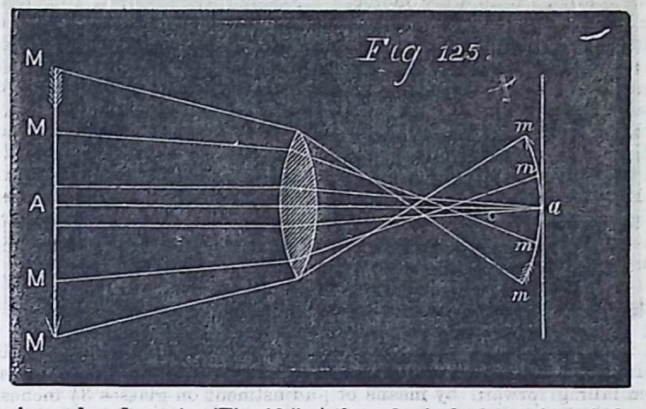


Fig 125.

The power used in the cheapest forms of lanterns is the double-convex lens, A (Fig. 124), or spectacle glass, of 2½ or 3 inches focal length; in those of somewhat better construction a plano-convex of 3½ inches focus is employed, as at B (Fig. 124), with a stop before it to diminish the amount of spherical aberration; while in the best of the ordinary or old-fashioned make, a pair of lenses are used for this purpose. Duboscq of Paris adopts a pair of double-convex lenses, as at C (Fig. 124). At the Polytechnic Institution, two plano-convex lenses with their curved faces towards the slide are employed (S, Fig. 124, represents the slide, that the proper position for all the lenses may be indicated), and in phantasmagoria lanterns either a pair of meniscus, as at E, or a plano-convex and a meniscus, as at F (Fig. 124). Such combinations are well suited to meet the requirements of flatness of field and good illumination with economic production. Nevertheless, they possess three defects which are of consequence in instruments of the highest class—viz., spherical aberration, chromatic aberration, and refractive aberration.

Spherical aberration is due to unequal refraction at different portions of a lens, the incident marginal rays, M, being more refracted than those nearest the axial ray, A; consequently they are collected at different foci, *m*, instead of on one plane, as shown in Fig. 125; the result being a more or less confused image of the object on the screen, according to the form and position of the lens in relation to the object (or slide). The greater the convexity of the lens, or the greater the inequality of the curves on its two faces in relation to the direction of the incident rays, the greater will be the amount of spherical aberration.

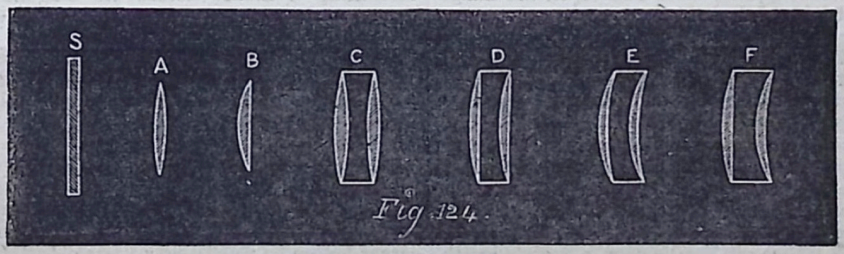


Fig 124.

It is, therefore, less in a lens of periscopic form, which renders the marginal rays longer than the axial rays, when the concave side is presented to the object to be reproduced as a reduced image and in reversed position for an enlarged image. Spherical aberration may be reduced, but never completely destroyed, by the proper use of a diaphragm or stop, by which we cut off the marginal rays to a greater or less extent, and in proportion as we decrease the size of the aperture of the stop, we secure a flatter field, and consequently increased definition or sharpness of the image; but as this method involves a considerable reduction in the amount of light transmitted, it is practically inapplicable to the case of magic-lantern objectives, except to an exceedingly limited extent. The spherical aberration of a lens may, however, be completely destroyed by a second lens of a contrary character; thus, convergent lenses must be corrected by divergent lenses of suitable curvature, and *vice versâ*. A convergent and a divergent lens may be cemented together, or they may be separated by a greater or less distance, or they may be of different diameters. Both lenses may be made of the same glass; but as a rule, the lens of a concave character is made of a different quality, as it also serves to correct the chromatic aberration. Such combinations act as a single convergent lens free from spherical aberration, and are termed *aplanatic*. It is impossible to construct a single convergent lens, or to associate two or more of them on a common axis, in such a way as to destroy spherical aberration; and though the contrary is asserted in many works on physics, we must recollect that this belief originated with the error in Sir John Herschel's memoir in the *Philosophical Transactions* published many years ago, and which, as previously stated, he only detected and corrected in 1861.

As the correction of the chromatic aberration is of greater importance than the spherical aberration, it frequently happens that the concave lens corrects too much or too little of the spherical aberration of the convergent lens: in the former case the combination is said to possess spherical aberration of a *negative* character, and the latter *positive*. A common form of lens corrected for spherical aberration is the achromatic plano-convex lens. If we take a combination of this character, of about 5 inches focus, as the power, we shall find if we place the flat side next to the slide that the image produced on the screen will be intensely sharp in the centre, but that the definition falls off rapidly towards the edges of the disc. If, on the other hand, the curved side of the lens be turned towards the slide, the image will not appear absolutely sharp in any one place, but there will be a uniformity of character in the definition, that points this out as the best position, even though the result is not all that could be desired. The shortcomings of a single achromatic lens may be overcome by painting or photographing the design on a slightly spherical glass, of such a radius of curvature that it will balance the amount of uncorrected spherical aberration of the lens. This method was adopted by the late Mr. James Holland, and also by Andrew Ross. These gentlemen, in order to be able to surmount the difficulties which they found were presented by the gas microscope, mounted the objects they wished to examine on small watch-glasses. The spherical aberration may also be destroyed by receiving the image on a concave screen, the curvature of which must correspond to the curvature of field resulting from the optical defect of the instrument. Such a method of destroying the spherical aberration is the least practical of any that have ever been suggested, though it might be employed in connection with the gas microscope where a large screen is not required for class demonstrations.

The usual method adopted for extending the area of good definition, is that of employing a second achromatic lens. Where, however, we are dealing with weak lights—such, for example, as the Argand burner—we can ill afford to lose the amount of light absorbed and reflected from the cemented surfaces of a second achromatic lens; hence, if we wish to show photographic slides, we are forced to rest content with a single achromatic combination, so it is of importance to adopt a power of the best possible form and of as short a focus as is compatible with good performance.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVI.—DISCOVERIES OF SIR HUMPHRY DAVY.

NEARLY a century ago there was born at Penzance, in Cornwall, a boy whose genius was distinguished by very remarkable precocity, who before he was two years old could speak fluently, and who could repeat a great part of the "Pilgrim's Progress" before he could well read it. He had an extraordinarily strong perception; for he would, at the age of five years, turn over the pages of a book as rapidly as if he were merely engaged in counting the leaves or in hunting after pictures, and yet, on being questioned, he could generally give a very satisfactory account of the contents; and the same facility was retained by him through life. But he was more remarkable out of school than for any great advance in learning. He excelled in story-telling, partly from books, particularly from old people such as had a rich store of traditions and marvels. Such was Humphry Davy, who, says his brother, was at this time a clever boy, but not a prodigy. He was regular in his school duties, but scarcely developed any extraordinary abilities. At the age of fifteen, his school education was considered completed, and his self-education, to which he owed almost everything, was about to commence.

But before entering in any way on the discoveries and inventions which Davy made and produced in the course of his too brief but useful career, we may be permitted to state what is known of his family. Davy himself was of humble origin, for his father was occupied as a carver in wood; but notwithstanding this, his connections were chiefly to be found among the yeoman class, of whom more exist and have existed for years in the western counties than in any other part of England, while his ancestors were small landowners, having long possessed an estate of limited extent at Varfell, in the parish of Lugdvan. He was sent, with his brother, John Davy, who afterwards acquired eminence as a chemist, geologist, and physiologist, and who wrote a biography of the subject of our sketch, to a school in Penzance, kept by Dr. Cardew, where, as it has been said—although he did as fairly as other boys of the same age—he gave no particular indication of the innate talent for which he was afterwards so remarkably distinguished, nor signs of his aptitude for chemistry and other kindred sciences in which he subsequently acquired such a world-wide reputation. His imagination in his earliest years was vivid and fertile, and many pieces of poetry are extant which were written by him when a boy at school.

On leaving school he settled to study. Early in 1795 he was apprenticed to a surgeon and apothecary in Penzance; and about this time he commenced his note-books, the earliest of which contains a plan of study, and hints, and essays, in which, "with all the daring confidence of youth, he enters upon the most difficult problems in metaphysics and theology, and employing a syllogistic method of reasoning (which, as he observes in his 'Consolations in Travel,' young men commonly follow in entering upon such inquiries), he arrives, as might be expected, at a conclusion contrary to the good feelings and common sense of mankind."

Next year Davy entered on the study of mathematics, and finished the elementary course; he was very systematic. But his favourite pursuit was metaphysics, and his rough notes show an acquaintance with the writings of Locke, Hartley, Bishop Berkeley, Hume, Helvetius, Condorcet, and Reid and other Scotch metaphysicians. These studies he soon associated with physiology. In 1797 he began in earnest natural philosophy; and in his nineteenth year he commenced the study of chemistry, with Lavoisier's "Elements" and Nicholson's "Dictionary." His experimental apparatus consisted of phials, wine-glasses and tea-cups, tobacco-pipes, and earthen crucibles; and his materials chiefly the mineral acids and the alkalies. He began to experiment in his bedroom, and sometimes he went down to the kitchen-fire with his crucibles. In four months he was in correspondence with Dr. Beddoes, relative to his researches on heat and light, and a new hypothesis on their nature, to which the experienced Dr. Beddoes became a convert. The result was Davy's first publication, "Essays on Heat and Light," in 1799, which had been in part written a few months before he had commenced the study of chemistry. "Such," says his brother Dr. Davy, "was the commencement of Humphry Davy's career of original research, which in a few years, by a succession of discoveries, accomplished more in relation to change of theory and extension of science than, in the most ardent and ambitious moments of youth, he could either have hoped or imagined possible." Most of the peculiar views developed by him were speedily abandoned; his brother admits that many of the speculations were wild and visionary, and adds what will readily be admitted, that "the wildest of them are most natural to a young mind just entering on the twilight of physical science, gifted with high power and a vivid imagination."

Davy, when nineteen summers old, among other things, concluded that oxygen, as it exists in the atmosphere, is a compound of real oxygen and a matter of light; that when a taper burns, this light is set free, while the wax unites with the actual oxygenous principle of oxygen, and melts "into thin air;" that when a man inspires, this "phosoxygen" (such was the name he put upon the ordinary oxygen of the atmosphere) is absorbed by the blood, carried to the brain, and there decomposed into true oxygen and light; and that the light thus liberated within the most intimate recesses of "the golden bowl," from which the stream of higher life appeared to permeate the body, is the nervous energy, and the proximate cause of sensation, perception, and emotion. In sad and sober earnest, the enthusiast was then a materialist; and this dazzling vision, which sanctified the divinity to his kindled imagination, was a compromise between his impersonal piety and the eminently practical but brilliant science by which he was taken captive. This eloquent episode appears in the *North British Review*, No. 3, as "Davy's Early Dream."

One of Davy's constant associates was Mr. John Harvey, a druggist at Penzance, who supplied him with chemicals. They frequently experimented together; and one severe winter's day, after a discussion on the nature of heat, the young philosophers were induced to go to Larigan River, when Davy succeeded in developing heat by *rubbing two pieces of ice together*, so as to melt each other. [Could we, by mechanical pressure, force water into a solid state, an immense quantity of heat would be set free.] This experiment Davy repeated with much *éclat*, many years after, in the zenith of his celebrity, at the Royal Institution. The pieces of ice for this experiment are fastened to the ends of two sticks, and rubbed together in air below the temperature of 32°; this Davy readily accomplished on the day of severe cold at Larigan River; but when the experiment was repeated at the Royal Institution, it was in the vacuum of an air-pump, when the temperature of the apparatus, and of the surrounding air, was below 32°. It was remarked that when the surface of the rubbing pieces was rough, only half as much heat was evolved as when it was smooth. When the pressure of the rubbing pieces was increased four times, the proportion of heat evolved was increased sevenfold.

Davy had already become the friend of Mr. Gregory Watt (son of the celebrated James Watt), and with him visited the most remarkable mines near Penzance, collecting specimens of rocks and minerals. And here, working the Wherry Mine, situated beneath the sands, and its shaft in the sea, young Davy saw a steam-engine at work, this being one of the earliest of Watt's steam-engines that had been introduced into Cornwall.

Meanwhile Davy's progress in medicine was such, that in the fourth year of his studies he was considered by Dr. Beddoes competent to take charge of the patients belonging to the Pneumatic Institution at Clifton, thus entering on his public career before he was twenty years old. He now applied himself with great zeal to complete his experiments and essays on light and heat; and, above all, on the effects of the gases in respiration. Of these, nitrous oxide was the first experimented on; and Davy's discovery of its wonderful agency was the origin of the researches which established his character as a chemical philosopher. In April, 1799, "he first breathed nitrous oxide: ten months of incessant labour were employed in making them; three years in detailing them. The author was under twenty years of age, pupil to a surgeon and apothecary in the most remote town of Cornwall, with little access to philosophical books, and none at all to philosophical men." (Davy's "Researches"). So intense was his application, and so little his regard for health or even life, that he nearly lost it from the breathing of the carburetted hydrogen, and was compelled for a time to leave the laboratory.

MINING AND QUARRYING.—XXXVI.

BY GEORGE GLADSTONE, F.C.S.

SALT.

COMMON SALT (CHLORIDE OF SODIUM); CHEMICAL FORMULA, NaCl.

DEFINITION—ABUNDANCE—GEOLOGICAL DISTRIBUTION—GEOGRAPHICAL—UNITED KINGDOM—AUSTRIA—SPAIN—GERMANY—RUSSIA—MEDITERRANEAN—AMERICA—ASIA—DEAD SEA—ELTON LAKE—AFRICA.

THERE are few articles more indispensable to the well-being of man than salt, and through the wise ordering of Providence there is scarcely one which is so widely diffused in nature. It is familiarly known as an article of food, being almost the only mineral substance which is eaten as such, and used alike by savage and civilised nations; but it is also very largely employed as a preservative of animal substances from decay, in the manufacture of other chemical products, and in a variety of minor ways. It occurs in nature both in the solid state and in solution; in the former case, as rock salt or saline incrustations; and in the latter, as salt springs and lakes more or less saturated, and in the waters of the sea.

The distribution of salt, geologically considered, is scarcely less extended in range than it is in geographical area. The principal accumulations of rock salt in England are in the Permian and Triassic deposits, but if we pass to the United States of America we shall find that the rocks which are attributed to the Salina period, on account of their general impregnation with salt, are of an antiquity equivalent to our upper Silurian. If, on the contrary, we pass eastward to the greatest deposits of rock salt in Europe, and, so far as is at present known, the greatest in the whole world—those extending immediately to the north of the Carpathian Mountains—we shall find that they belong to the Tertiary epoch. Further, we shall presently see that the process of deposition is still going on in some of the inland seas and lakes, especially those of Central Asia; and the same mineral is not unfrequently one of the products of volcanic eruptions. Its occurrence, therefore, extends in geologic time from the older Palæozoic to the present period, and is due to the most opposite of agencies—fire and water.

Our own country occupies the foremost place in this industry. The United Kingdom not only furnishes almost the whole of the salt which is consumed within her borders, but also exports large quantities to India, the United States, and other countries. The annual produce is about one million and a half tons. By far the greater portion is raised in two counties—Cheshire and Worcestershire. About two hundred years ago, while boring in search for coal at Northwich in the former county, a bed of rock salt was discovered instead, at a depth of about 100 feet from the surface, which proved to be 90 feet thick. This was underlaid by a stratum of indurated clay, and for more than a hundred years the proprietors of the mines were satisfied to work this bed without exploring further. Subsequently, on boring through the underlying clay to the depth of a little over thirty feet, a second bed of rock salt was found, which proved to be of the same thickness as the upper one; the lowest portion of the lower bed was, moreover, much freer from earthy admixture than the rest, the purest stratum being from twelve to fifteen feet thick. These two deposits occupy a depression of about a square mile in area, immediately to the north of the town, and have been the great source of supply from the time of their first discovery to the present day. The salt is prepared for use at Northwich, and then sent by craft to Liverpool for shipment. At Lawton, in the same neighbourhood, three beds of rock salt were found about a hundred years ago, the thickness of the two upper ones being four and twelve feet respectively, while that of the lowest is upwards of 70 feet. It was the discovery of this third bed, and the circumstance that the lower portion of it is the purest, which led the proprietors of the Northwich mines to carry their explorations down into the second bed.

Wherever any quantity of rock salt occurs below the surface of the earth, it follows almost as a matter of necessity that there will be brine springs more or less saturated, because the water in percolating through the saliferous strata will dissolve out the salt. In most places, therefore, where rock salt is procured, the water pumped up is also preserved for the sake of that which is held in solution; while in many cases, where the layers are very thin and much mixed with earthy matter, the attention of the miner is exclusively devoted to the brine.

In Worcestershire, and particularly in the neighbourhood of Droitwich and Stoke, brine springs are very numerous, and large quantities of salt are made. At the former they are met with at a depth of 175 feet, but at the latter the borings have to be carried down to double that distance. They are usually lined with iron pipe or wooden casings, in order to keep out any fresh-water springs which may be encountered in the upper strata. The saliferous deposit extends also into Staffordshire, at Shirleywich, Weston, and other places; and in Lancashire powerful brine springs occur at Barton.

About ten years ago a bed of rock salt was struck in boring for water at Middlesbro'-on-Tees, at the great depth of 1,206 feet, which was found to be 99 feet in thickness, and underlain by a sort of conglomerate consisting of salt and limestone mixed together. The product of the brine which is pumped up from this depth, after evaporation, gives 96·6 per cent. of salt, the rest being principally gypsum. The strata bored through belong to the same geologic period as those of Cheshire.

In Ireland a considerable deposit of rock salt, in the neighbourhood of Carrickfergus, is worked to the extent of some 25,000 tons annually; but there is no deposit of any consequence in Scotland.

With such sources of supply as these, the unlimited one which encircles the British Isles is almost neglected, especially as the small per-centage in sea-water will not admit of its being evaporated down by artificial heat, and the climate is scarcely suitable for doing it otherwise. Nevertheless, some quantity of sea salt is manufactured in Hampshire, on the Tyne, and along the shores of the Solway Firth.

Turning to the continent of Europe, the most remarkable deposits of salt which we have to notice are those in the Empire of Austria. The province of Galicia can boast of the most extensive one known. It extends over an area of some 10,000 square miles, and is principally worked at Wieliczka and Bochnia, two considerable towns twenty-two miles apart, almost the entire population of which is engaged in the salt trade. The underground workings at the former mine are over thirty miles in length, constantly opening out into large halls, the dimensions of which sometimes attain to about 150 feet in length by 80 in breadth, and 100 in height, being by far the largest artificial excavations in the whole world. They are carried to a depth of 860 feet, the greater part of it through solid salt, the beds of the mineral being thicker than the earthy partings. The annual product of this mine is about 48,000 tons. Rock salt is common in many parts of the Eastern Alps and of the Carpathians, and is worked largely in the district of Marmoros, in Hungary, which yields annually about 28,000 tons; and at Maros-Ujvar, Vizakna, and Parajd, in the province of Transylvania, whence 68,000 tons are obtained yearly. In the region of the Alps the salt is more intermixed with earthy matter, and occurs in smaller masses, so that little rock salt is worked; but very large establishments exist for pumping up the brine and evaporating it down. The principal centres of these operations are Ischl, Hallstadt, Hallein, Aussee, Hall, and Soovar. About 100,000 tons are manufactured annually at these works. On the coast of the Adriatic nearly 30,000 tons are made every year by evaporating the sea-water, which is there somewhat richer in salt than the water of the Atlantic.

Spain possesses a remarkable deposit at Cardona, where a solid mass completely fills up the head of the valley, and is quarried in an open working, the excavations having left exposed a lofty cliff composed almost entirely of rock salt. The works, however, at Añana, in the Basque provinces, are the largest in the country.

Salt springs occur over a very wide area in Germany—viz., at Reichenhall, in Bavaria; at Friedrichshall, Sulz, and other places in Würtemberg; at Halle, Stassfurth, Schönebeck, and Artern in Prussia, etc. At these places brines are obtained which contain from 10 to 26 per cent. of chloride of sodium. The higher figure is almost equal to that of a saturated solution, the maximum quantity found in the mother liquors of brines being 28·8 per cent. In many other places, such as Sulza, Kösen, Dürrenberg, Münster am Stein, etc., there are springs containing smaller per-centages of salt, which are utilised in a way to be described subsequently.

The Putrid Sea, and the lakes or lagoons which immediately border it and the Sea of Azov, are highly impregnated with salts, of which the greater portion is the chloride of sodium. Some of

the latter have as much as 18 per cent. of the common salt, together with about 8 per cent. of the sulphate and chloride of magnesium. The Putrid Sea contains rather more than 14 and 3 per cent. of the sodium and magnesium salts respectively.

On the Bessarabian shores of the Black Sea considerable quantities of salt are annually collected, and the limans or lakes from which the supplies are derived furnish a very instructive illustration of how deposits of rock salt may accumulate. From the mouth of the Danube as far as the Dnieper all the rivers, before terminating in the sea, expand into lakes of greater or less extent, which are separated from the sea by natural dams. The water flows into the sea through an opening in the dam, while, on the other hand, during storms, sea-water flows into these limans. In the water of the extensive limans which are formed by the larger rivers, as the Dnieper, Dniester, etc. etc., which receive a large volume of fresh water, the proportion of salt is so small as not to be perceptible to the taste. The three Bessarabian limans, however, situated to the south-west of Odessa, become partially dry every summer, and deposit their salt in crystals, which, in the neighbourhood of the shore, are of small size, and form beds of only ½ to 1 inch thick; but in the middle of these limans the crystals are larger, and often form beds 1 foot in thickness. Nearly 100,000 tons of salt have been collected from these limans in the course of a year. This is the more surprising, as the waters of the Black Sea itself only contain 1·4 per cent. of chloride of sodium.

Along the coast-line of Portugal a considerable amount of sea salt is collected, and on the shores of the Mediterranean the evaporation of the sea-water for the same purpose is carried on very extensively, especially along the south coast of France and in the islands of Sardinia, Sicily, and Cyprus.

In America the most remarkable region is the Valley of Utah, or the Great Salt Lake. The lake itself is about 300 miles in circumference, and the waters are intensely saline; besides which the shores all round, for some considerable distance, are encrusted with this mineral. In the southern hemisphere there are salt plains in Peru and other parts, where rain scarcely ever falls; some of them are high up the Andes, that of the Pampa de Sal being nearly 15,000 feet above the sea-level. The salt in many places permeates the soil, and in others forms layers 8 or 10 inches thick. It is associated there with nitrate of soda and biborate of lime. The salt lakes which are common in the plains of Patagonia contain almost pure chloride of sodium.

In Asia there are several localities where remarkable deposits of salt occur. At Lahore, and in Affghanistan, the rock salt attains a great thickness, as much, in some cases, as 100 feet. In Persia there are mines wrought, which, although the layers are only 6 to 18 inches thick, yield salt of great purity, so that pieces of 2 inches in thickness can be procured from them which shall be perfectly transparent. The island of Ormuz, in the Persian Gulf, consists principally of rock salt; and many of the almost rainless deserts in that country are covered with a saline efflorescence which glistens with dazzling brightness under the burning unclouded sun.

Central Asia, moreover, possesses many inland seas and lakes the water of which is intensely salt, and is doubtless precipitating solid salt, as, in consequence of their having no outlet, the quantity of saline matter must be constantly increasing. The largest of these is the Caspian, but the water of this is not so salt as that of some of the smaller lakes. The Sea of Aral, the Dead Sea, Lakes Van, Ooroomiah, and Balkasch, are all salt; that of Ooroomiah the most highly impregnated of all, as it lies in a region where all the soil is more or less salt, and some of the small streams which feed it pass through considerable beds of solid rock salt. One of these occurs in Red Mountain near Tabreez, from which a stream runs into the lake, the water of which is too salt for comfortable use; and another of these is at Khoy, about ten miles north of Lake Ooroomiah. The rock salt is remarkable for its extreme purity, as limpid as rock crystal, and without even a trace of either the sulphate of lime or of magnesia. The lake is 82 miles long by 24 broad, and the water contains 19 per cent. of chloride of sodium.

The Dead Sea is not so remarkable for the quantity of this salt as for the general total, those of magnesium and calcium being usually about the double of that of sodium. The relative proportions, however, vary very greatly, according to the season of the year, so that the recorded analyses of the waters are widely discordant; but this very circumstance is a matter of no little interest, as illustrating a chemical fact which may have a good deal to do with the formation of other deposits of rock salt. The Dead Sea lies more than 1,300 feet below the level of the ocean, and whether it was ever connected with it or not—a point upon which physical geographers are far from being agreed—it is certain that whatever salts are washed down by the Jordan and other rivers must now remain there, the inflowing water being carried off by evaporation alone. Now the Jordan, which pours into it the greatest quantity of water, contains twelve times as much chloride of sodium as of chloride of magnesium in solution; and at Kashum Usdum, on the south-west shore of the lake, is a ridge of rock salt 100 to 150 feet in height and five miles in length, the water draining from which will also bring down large quantities of chloride of sodium. How, then, it will be asked, does it happen that the quantity of magnesium is so much in excess of that of sodium? The explanation is this: that the solubility of chloride of sodium in water diminishes, the greater the amount of chloride of magnesium therein dissolved. The more, therefore, the latter becomes concentrated by evaporation, the more rapidly is the chloride of sodium deposited. As the surface water of the Dead Sea is practically a saturated solution, containing in the dry season more than 26 per cent. of saline constituents, the natural inference is that a deposition of common salt is taking place at the bottom, more or less rapidly according to the season of the year.

There is another salt lake in the depressed region of Central Asia, which is of considerable interest. The surface of the Elton lake is somewhat below the level of the ocean, and the streams which supply it with water pass through districts where the soil is highly impregnated with salts. The lake is very shallow, and therefore presents a large surface in proportion to the quantity of water it contains. Being situated in a climate where the changes of temperature between winter and summer are very great, the waters of the lake are likewise subject to great changes in their chemical composition. They are, in fact, a concentrated mother-liquor from which, for a long period, common salt has been deposited, and still continues to be deposited during the summer months, the water brought into the lake being at this season less than that which is removed by evaporation. In general, a deposit of common salt takes place in this lake every summer. From 1747 to 1851 there was only one year, 1776, in which such deposition did not take place. The summer of that year was, however, very rainy and cold. At the distance of two versts from the margin of the lake a well was dug. The uppermost strata of salt were two-thirds of an inch to 2½ inches thick. After forty-six such strata had been penetrated, their thickness increased to about 8 or 9 inches, and at length, after penetrating 100 strata, a very compact bed of salt was reached. Analyses have been made of the waters of the lake at different seasons, showing great variations in the relative proportions of the chlorides of sodium and magnesium.

Per-centage Proportions.	By Göbel, in April.	By Erdmann, in August.	By H. Rose, in October.
Chloride of sodium . .	13·124	7·451	3·83
Chloride of magnesium .	10·542	16·280	19·75
	23·666	23·731	23·58

At first sight the great difference in the three analyses may appear somewhat surprising. The sums of the two salts given are, however, nearly equal in all three; as the one of these two salts decreases, the other increases, and *vice versâ*. The water analysed by Göbel was obtained in spring, when the influx of water was very great, and the evaporation very slight; whereas Erdmann's specimen was obtained in summer, Rose's in autumn. In proportion, therefore, as the amount of water removed by evaporation becomes greater, the chloride of sodium diminishes—a deposition of it taking place—while the chloride of magnesium increases. A time will come when the Elton lake will have become quite saturated with the latter; the deposition of common salt will then increase, for a saturated solution of chloride of magnesium can hold only 1 per cent. at most of common salt in solution. Circumstances will then be still more favourable for the preparation of salt from the water of

the Elton lake, which even now yields about two-thirds of the entire amount of this substance consumed in Russia; it will, however, become less pure, containing more chloride of magnesium.

Africa also possesses salt plains, and this mineral constitutes one of the most important articles of commerce in the deserts of the interior, whole caravans being laden with this article alone. One of these plains lies within fifty miles of Annesley Bay, on the Red Sea, where at least 750,000 pounds of salt are produced weekly; the pieces of salt (which usually weigh something over one pound each) serve as a circulating medium in Abyssinia until required for consumption.

THE LATHE.—XV.

By Henry Northcott.

SELF-ACTING TURNING AND SCREW-CUTTING.

Ordinary plain traverse turning may be performed in any self-acting lathe, whether the traverse of the tool is derived from a leading screw, or from a rack and pinion; but screws can only be properly cut in lathes furnished with a correctly-made leading screw and set of change-wheels. Screw-cutting is always a secondary operation, as the blank shaft out of which the screw-groove is to be cut must first of all be carefully turned to the proper size with the ordinary traverse. To turn up a plain cylindrical shaft or bar it is necessary first of all to correctly centre the rough iron, and to straighten it. The centre mark is in the first instance knocked into the ends by a hard steel centre-punch, ground to about the same angle as the lathe-centre. If the shaft be longer than the required finished shaft by much more than is necessary for facing up the ends, it is put between the lathe-centres upon the preliminary centre-marks or indents made with the punch, and before further trouble is taken in centering or in straightening it, the ends are roughly turned off so as to leave the bar only just long enough to allow the ends to be finished up when the shaft is properly turned. If a number of such shafts have to be turned, they are all served in this way before any further step is taken in turning any one of them. Frequently the whole operation of centering, cutting off the ends, and straightening necessary to prepare work for the turner, is prepared in a separate rough lathe, and by another workman, so that when the shafts reach the self-acting lathe they are quite ready for turning up. This system, however, can only be carried out in large engineering works where the quantity of turned work is sufficient to render a subdivision of labour advantageous. Ordinarily the turner has to prepare his own work for turning, and the cutting off to the right length will be his first labour. This being effected as explained, the shaft has to be correctly centered. Two light centre-marks are again knocked into the two ends of the bar, which is then placed between the lathe-centres, as before; but for the ordinary plain screw headstock centre is substituted a cutting centre—that is, one with its cone filed down to four cutting edges—and this is only gently forced against the bar so as to allow of its being easily rotated.

A driving dog or carrier having been slipped upon the bar and adjusted, and a flat-faced non-cutting tool placed in the slide-rest, the lathe is set in motion, and a little oil dropped on the point of the cutting centre. The flat face of the tool is simply used to apply pressure. It is placed just at the end of the shaft, and carefully brought up against its surface as it rotates. If the centre-mark knocked into the end of the bar be not in the centre of its face, the shaft will run out of truth or excentric, and the object of pressing a flat-faced tool against it is merely that the tool coming first of all in contact with the place farthest from the correct centre may force that part inwards, and oblige the cutting centre of the lathe to cut its way towards the place to which the pressure is applied. The tool must be very gradually forced against the shaft, and simultaneously the cutting-centre must be forced against the end; but until the correct centre of the bar is found—which is seen by the tool pressing about equally around its periphery—only enough pressure should be applied to the cutting-centre to keep the bar fairly in its place, and prevent it falling from the lathe-centres. When, however, the cutting-centre has arrived in the centre of the bar, it may be pressed up to its cut with greater force until it has scraped out a pit deep enough for the bar to be turned on. The proper depth of the centre-mark depends upon the size of the work; but it is not a matter needing any great degree of exactness.

One end of the shaft being centered in this way, the lathe is stopped, the carrier slipped along to the opposite extremity, and the position of the bar in the lathe is reversed, in order that the same operation may be performed on its other end.

It is usual, after the bar has been square-centered, to drill a very small hole up each end at the bottom of the centre-mark; this may be done in the lathe or not, as may be most convenient. The size of the hole generally varies in diameter from, say, one-twentieth of an inch to one-quarter, and from three-sixteenths of an inch to one inch in depth, according to the size of the shaft. The chief function of these holes is to carry oil for lubricating the centre, and to prevent the extreme points of the lathe-centres from coming into contact with the metal.

The next point to attend to is that of straightening the bar, and when this is effected it is ready for turning. It is, of course, assumed that the shafts are not brought to the lathe with any considerable deviation from the straight, as rough straightening should be performed in the forge, and always previous to the final centering of the bar. The turner has frequently, however, to remove some slight bends from his work which would perhaps otherwise prevent it from holding up to size. And this more exact straightening is not quite so easy to perform as a looker-on would imagine. Some workmen will straighten a shaft with a few blows, and in as few minutes. Others will perhaps hammer away for an hour upon it, and leave it worse than when they commenced. And occasionally a single tap with the hammer may chance either to suddenly rectify a shaft which had almost exhausted the workman's patience, or it may as suddenly and as inexplicably throw out of straightness one that apparently needed but this single blow to render it perfect. The usual method of straightening is very simple. The shaft is mounted between the centres, and is moved round slowly, whilst a piece of chalk is carefully applied at those parts where the excentricity is greatest. When the lathe is stopped the workman observes the position of these chalk marks, and if they are all on the same side of the bar, he concludes that he has only one bend to straighten; whilst if these chalk marks are disposed around the bar, or at opposite sides of it, he knows that he has to rectify two or more distortions.

A single bend is easily put straight, but when there are more there is a chance of throwing one place out whilst hammering another straight. If there be only one bend in the shaft, the workman places a block of wood on the lathe-bed just underneath the spot he judges to be the origin or middle of the bend; he takes a small iron bar as a lever, and using the block of wood for a rest or fulcrum, he applies such a pressure to the under part of the shaft as in his judgment the extent of the bend may demand. The end of the lever, which should be flat, is applied to the same side of the shaft as the chalk marks, the shaft being shifted round to bring that side undermost. It is not upon the unaided pressure, however, that the workman relies, but at the same time as he presses upon the lever with his left hand he plants a blow with a hammer upon the shaft at a point as nearly as possible opposite to that in contact with the lever. The heaviness of the blow is a matter of importance, but of this, also, nothing but experience will enable one to judge.

After this the lever is removed, and the chalk is again used to indicate the position of the bend and the effect of the blow. If the marks repeat themselves on the same side of the shaft, this shows that the treatment was not sufficiently severe; if they appear all on the other side, it was too severe; and if some are placed one side and some on another, the effect of the blow has been to knock a simple bend into a compound one. The treatment must be continued according to the judgment of the workman until the shaft is straight enough for turning up. The chief points upon which success depends are the position of the end of the lever, the pressure applied, and the weight of the blow. With all three correct, a single blow will straighten the bend.

The shaft being properly centered and straightened, it is ready for turning. A carrier is fastened upon one end of the shaft, which is placed again between the lathe-centres, and a tool is fixed in the slide-rest, and the latter is moved along the bed, so that the tool may commence at the extreme right hand of the shaft. The bulk of the metal should be removed at the first cut, and a second or at most a third cut should finish the shaft. But the

whole length should be roughed over before a finishing cut is taken.

The circumferential speed, the shaft being good wrought iron, should be about 18 or 20 feet per minute; the traversing speed of the tool should be about fifty cuts to the inch—that is to say, the work should rotate about fifty times whilst the tool travels one inch; and the edge of the tool should be kept well lubricated and cooled by the continuous dropping upon it, from a can placed at a slight elevation, of soda-water or soap-suds. If the shaft be long and slender, the back-stay of the slide-rest will have to be used to hold the shaft in position against the cut, which tends to force it out of line. This stay is generally adjusted to follow the tool, but it may be fixed to precede it in such cases as where the surface of the work has been previously rendered quite true. But the latter disposition, although sometimes convenient, is not a usual one.

After the shaft has had a good stiff roughing cut removed from it, from some cause or other, it is generally left much bent and distorted. This is at once discovered on rotating it freely without the back-stay and out of contact with the tool, when it is very frequently found that the shaft runs considerably out of truth, and requires as much straightening as it did to prepare it for the lathe in its rough bar form.

The re-straightening is performed in the same manner as before, but it will be found that a less pressure upon the lever and a lighter blow with the hammer are now sufficient to correct a given distortion.

The finishing cut is taken in the same way as the roughing cut, but greater care should be exercised in sharpening the tools and in conducting the operation generally. Sometimes the finishing cut is taken with a peculiar form of tool, called a spring tool, from its being so shaped as to spring away from the cut if any great resistance be encountered, which takes the merest scraping of a cut, and if well sharpened and well lubricated with the water, leaves a very smooth glossy surface upon the work, instead of the slightly roughened surface left by the ordinary turning tool. Shafts are, however, usually polished either by removing the traverse marks with a file and then grinding with emery and oil, or in certain cases by grinding the surface at once by the application to it of a rapidly rotating emery wheel, the shaft itself being meanwhile slowly revolved. The two end-faces of the work need very little doing to them, but this little should be effected previous to polishing by just skimming them over with a sharp knife-tool kept well wetted so as to leave a polish.

Turning of every kind is practised much in the same way as that described, but the work may have to be fastened to the lathe differently, and the preliminary adjustments may not be the same. For instance, in turning up a plane surface, say a flat disc, the object would either be fastened by bolts or clamps to the face-plate, or held in the four-jawed chuck, whichever might be found most convenient. If the disc be tolerably thick, and with a hole through its centre, it is generally advisable to drive it on a steel mandril, as in that way the turned portion will be true with the hole itself. The traverse of the tool for this class of work is derived from the cross slide of the rest, and the direction in which it moves is from the centre towards the circumference. In order to keep the cutting speed about constant, it is necessary to run the lathe slower as the tool recedes from the centre, because with the same speed of the lathe the cutting speed is obviously increased as the tool approaches the circumference of the circle. The alteration of the lathe-speed is of course effected by shifting the driving-band on to a larger step of the cone-pulley upon the lathe-spindle.

A flat ring or socket is first bored out to the required size, and if necessary the hole is smoothed or polished by grinding with emery upon a leaden lap. The rough ring is then driven upon a mandril, and its face is turned down to its size, after which the two edges or sides are faced up with knife-tools.

A steam-engine connecting-rod is made larger in the middle than at the ends, and the longitudinal section is sometimes bounded by two curves of high radii, and sometimes by four straight lines forming portions of a double cone. To turn a rod with a curved "belly" needs a special motion of the tool, and this cannot be obtained without special mechanism. But when, as is very often the case, the rod increases in size regularly towards its middle, it may be turned in an ordinary self-acting lathe by moving the right-hand lathe-centre out of its true centre-line. When both centre-points are in their usual position the point of the tool, in running along the bed, will describe a line parallel with the line joining the two lathe-centres; but when one of the lathe-centres—say the right-hand one—is moved out of the true centre-line, the line described by the tool's point is no longer parallel with the new line joining the centre-points, but forms an acute angle with it. If the connecting-rod be in the lathe, and the turner begins as usual at the right-hand end, the lathe-centre at that end is shifted a little nearer the tool. Under this arrangement, as the tool travels towards the other headstock, the distance of its point from the line joining the two centre-points will become greater, and as this distance forms the radius of the turned circle, the diameter of the connecting-rod will also increase so as to form a tapering rod. When one-half of the connecting-rod has been thus turned, the rod is reversed, and the other half turned in the same manner. The actual distance the lathe-centre must thus be thrown out of its line in order to produce any given taper is generally a matter of experiment. The workman commences with a certain distance, and he judges from the cut whether this is too little or too much, increasing or reducing it as he finds necessary. The exact distance necessary depends upon several conditions which may vary for each end of the same rod.

An excentric for moving the valves of a steam-engine is another article which needs a little care in turning it. The excentric-hole is first bored out in the lathe whilst attached to the face-plate. This allows a mandril to be passed through it, when it is placed between the lathe-centres, and the flat sides of the excentric are faced up just as though it were a circular disc. Thus far is plain sailing, but the edge of the excentric cannot be turned upon the same centres; so it becomes necessary to find two others which will bring the edge concentric. If the hole through the excentric be large, or the excentricity small, the two new centres may fall within the ends of the mandril; but if they do not, two collars have to be fastened upon the mandril, one at each end, to receive the new centre-points, and upon these the edge of the excentric is turned to shape. The greatest care must be taken in locating the new centre-marks, or the excentric will run out of truth, and give trouble when working. Their correct position is found by taking the extent of excentricity between the points of a pair of dividers, and with this as a radius, and from the centre-marks of the mandril, describing or scratching an arc upon each end of it. This shows the distance of the new centres from the true ones. The direction of the excentricity is found by placing the mandril in the lathe with the line joining the two centres of the excentric horizontal, and striking a horizontal line upon each end-face of the mandril with a properly-adjusted scribing block. The greatest care must also be taken, whilst turning up the excentric, that it does not slip round upon the mandril, as this, by altering the relative positions of the several centres, necessarily throws the work out of truth.

In turning out an ordinary screwed bolt the workman first turns the blank bolt to its proper size, making a round-bottomed groove in it at the place where the screw-thread has to terminate, of about the same depth as the screw-groove, but no deeper, or the bolt will be unnecessarily weakened. The ordinary traverse is not deep enough for cutting the thread, so the change-wheels of the lathe must now be called into use to move the tool instead of the usual mechanism, that is, supposing the lathe has both sliding and screw-cutting apparatus. The lathe leading-screw has, say, two turns per inch or half an inch pitch, and the thread to be cut upon the bolt is to have eight turns per inch; then we must connect the lathe-spindle to the leading screw through such a train of wheels as will drive the leading screw round twice whilst the lathe-spindle and work rotates eight times. A pinion of 20 teeth on the lathe-spindle gearing into a wheel of 40 teeth on the intermediate socket will drive the socket round half as fast as itself, and a wheel of 60 teeth on the same socket gearing into one of 120 teeth on the leading screw, will reduce the speed of the latter again by one-half. With this train of wheels, whilst the lathe rotates eight times, the intermediate wheels will rotate four times, and the leading screw will rotate twice, which is what is wanted to cut a thread of eight turns to the inch.

The tool must be shaped to suit the thread. It should be kept sharp and well lubricated at its cut, or bad work will be

produced. When the tool reaches the groove cut as before instructed, it is withdrawn from its cut, and run back again by reversing the lathe, as already explained. To cut up the thread of a screw, of, say, twenty threads or complete convolutions to the inch, the lathe must rotate twenty times whilst the tool travels one inch, and with a pitch of two to the inch the leading screw will require to rotate twice to produce that extent of movement. A train of wheels must therefore be arranged to give the leading screw two rotations to twenty of the lathe. A pinion of 20 teeth on the lathe-spindle gearing into a wheel of 50 teeth as an intermediate, and a wheel of 30 teeth on the intermediate socket gearing into one of 120 teeth on the leading screw, will answer this purpose, as $20 \times 20 \div 50 = 8$, which is the number of times the intermediates will rotate to twenty of the lathe-spindle, and $8 \times 30 \div 120 = 2$, the number of rotations of the leading screw when driven from the spindle by these wheels.

In the same way, to cut a screw of the same pitch as the leading screw of the lathe in use, the spindle and the screw must have equal angular velocities, and a pinion of 40 teeth will be placed upon the lathe-spindle, and another of the same size on the leading screw, any large wheel that will gear with the two being used as an intermediate.

To cut a spiral of one complete turn in $2\frac{1}{4}$ inches with a two per inch leading screw the lathe must make one rotation whilst the tool travels $2\frac{1}{4}$ inches, and to cause this travel the leading screw must rotate $2\frac{1}{4} \times 2 = 4\frac{1}{2}$ times. The wheels must therefore be such as will give $4\frac{1}{2}$ turns of the leading screw to one of the lathe, or 9 turns to 2.

In this case the driving-wheels must be larger than the driven, as the speed has to be raised instead of lowered, in the proportion of 9 to 2. A wheel of 90 teeth on the lathe-spindle, and one of 20 teeth on the leading screw, with an intermediate to connect them, would give the speed, but it is generally preferable to use larger driven wheels, and to divide the difference between the drivers and the driven wheels amongst the two sets, so that a pinion of 100 teeth on the lathe-spindle gearing into an intermediate of 50 teeth, and an intermediate of 90 teeth gearing into a wheel of 40 teeth on the leading screw, would be a better train for the purpose.

Lathes are generally furnished with the following wheels, which are sufficient for almost any pitch—viz., 20 (sometimes 21, 22, 23, 24), 25, 30, up to 120, rising five teeth to each wheel, with an extra 40-tooth wheel for equal speeds. This makes 22 wheels, which is considered a full set. The four wheels between 20 and 25 are useful for odd pitches, and although very seldom needed may chance occasionally to save a good deal of trouble.

The pitches most often wanted are those for the ordinary Whitworth standard screw-threads of 20, 18, 16, 14, 12, 10, and 8 turns to the inch, and 4, 2, and 1 to the inch for lathe leading-screws. These pitches are all easily obtained by simple mental calculation; sometimes, however, odd pitches are met with for which the proper wheels are not so obvious; but the following rules, taken from the author's treatise on "Lathes and Turning will remove any remaining difficulty:—"The pitch of the required screw, divided by the pitch of the leading screw, will give the ratio of the number of revolutions of the leading screw to the number of revolutions of the lathe-spindle. Thus, supposing a pitch of seven to the inch to be required, the number of revolutions of the lathe-spindle will be seven to four of the leading screw, the lathe having to revolve the number of threads in the inch of the required screw whilst the leading screw revolves the number of times necessary to move the tool one inch. Knowing the ratio the speed of the screw bears to that of the work, it is an easy matter to calculate the wheels which will give these speeds.

"Many workmen can calculate the changes required for any whole number of threads, but cannot do so for any broken or fractional pitches. In reality fractional pitches are almost as easily calculated as whole numbers. We have only to multiply the fractional pitch by any number that will eliminate the fraction, and then to multiply the number of threads of the leading screw by the same number; the two numbers thus obtained will be the number of revolutions as before. For example, suppose we require to cut a screw having a pitch of $1\frac{3}{10}$ inch. Then $1\frac{3}{10}$ multiplied by 10 is equal to 13, which is the number of revolutions for the lathe-spindle.

"Also 4 multiplied by 10 is equal to 40, the number of revolutions of the leading screw.

"Again, if we want a thread of $\frac{3}{22}$ of an inch—

"$\frac{3}{22} \times 22 = 3$, number of revolutions of lathe-spindle.

"$4 \times 22 = 88$, number of revolutions of leading screw."

These examples were calculated for a leading screw having four turns to the inch.

SOLDIERING.—VII.

BY A STAFF OFFICER.

TRAINING (*continued from Page 219*).

It follows from what we said about the formation of troops at the end of our last paper, that if a small body of troops gets into a position towards the flank of another, it has acquired an immense advantage over it. For instance, from the position C D (Fig. 6) men could bring a tremendous fire to bear on A B, while A B would have very great difficulty in replying to it at all. It would, in fact, be necessary to get A B into a new position, more nearly parallel to C D, or in its turn taking C D in flank. The difficulty of performing this latter operation is, of course, enhanced by the fact that it must be undertaken under very effectual fire from C D. Hence it is easy to see that it will be constantly necessary to take care that troops are not exposed to the risk of being "taken in flank." Now the formation of bodies "in echelon" securely protects one flank, and as we can usually be pretty sure from the nature of the undertaking which flank is most exposed to risk, this in fact is, as a rule, sufficient.

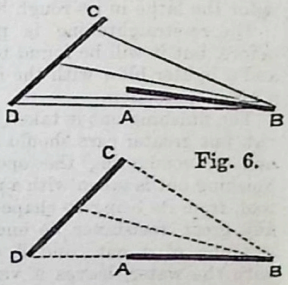


Fig. 6.

There are three kinds, as shown in Fig. 4 (p. 216). Short echelon protects both flanks to some extent. Direct echelon protects the flank which is thrown back—the right, for instance, in the illustration. In oblique echelon, similarly, the flank thrown back from the general position of the echelon, but that which is, in fact, thrown forward in making the movement, is protected. In the illustration this is the left flank. How this protection is afforded is evident, for each small portion would be protected from any enemy assailing the flank I have in each case named, by the fire of the portion next behind it. The near one is not directly protected, but is the furthest from the enemy. In oblique echelon we have the advantage that the line is gradually being transferred during the process of the movement to a position to the right or left of that which it formerly occupied. When the whole body has arrived at the required position, line is easily re-formed again either into the original direction of front of the line, or into the direction of front common to each separate portion of the echelon, or to a front more or less oblique than that of the echelon.

It should be observed that the word "front" is used in somewhat different manners. It is used in its simplest sense to imply that portion of a position occupied by troops which is nearest to the enemy. Then from the fact that positions are in general taken up by armies in successive lines, it has come to be used of the general *direction* of the line running along the part of the position or formation supposed to be nearest to the enemy. It is in this sense of the word that we speak of a "change of front." We mean that we change the direction of the line running along that part of the formation of the troops which we intend to be nearest to the enemy. Then again the word is used as a sort of abbreviation of the expression "length of ground taken up from one flank to the other by the troops occupying the front (in the first sense of the word) of the position (or formation)." Thus troops which when in line occupy from one flank of the line to the other 1,000 yards, are said to have "a front of 1,000 yards." The difference between a change of position and a change of front is that in the case of

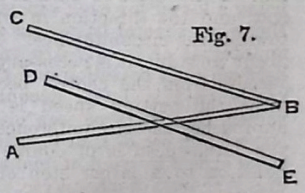


Fig. 7.

a "change of position" the whole body of troops occupying the front is transferred to a new position, no part of which has been occupied by any part of the line in the original position: in the case of a "change of front," the new front either intersects the old, or meets it in some point without intersecting it. Thus to transfer a body of troops from D E to C B (Fig. 7), or from C B to D E would be to "change position." A change from A B to either C B or D E, would be a "change of front." Thus a change of position may or may not involve a change of front also. The front of a new position may be parallel to the front of the old position or oblique to it.

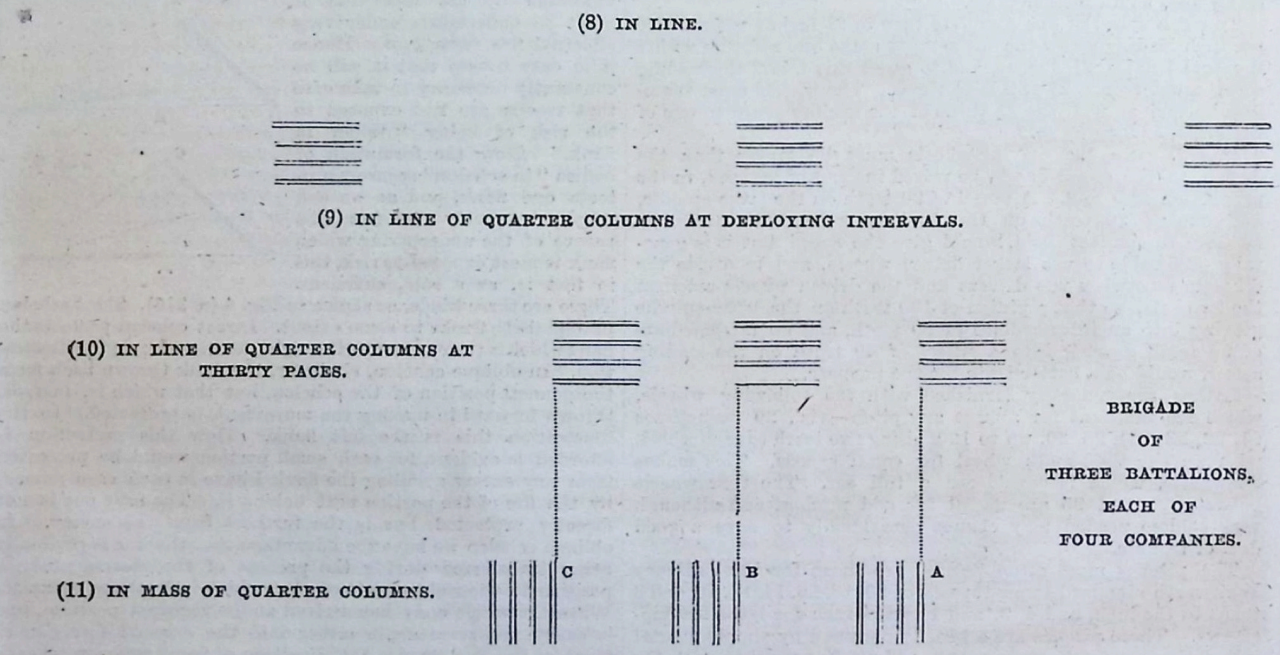
This will be sufficient for our purpose in regard to infantry drill.

When bodies of infantry larger than battalions are brought together for purposes of drill, two or three battalions are usually formed into a "brigade," two brigades into a division, and two or three divisions into a *corps d'armée*. These large bodies require to be able to form lines and columns just as the smaller do. In their formation there is this difference, however. The battalions are themselves when in line so formed that each man stands shoulder to shoulder, and no space is left from one flank of the battalion to the other, a space of forty-eight inches being allowed for each officer in the line just as for each man. But when several battalions are placed side by side one another an interval of twenty-five yards or of thirty paces is allowed between each battalion and the next. The battalion is usually—partly on this latter account, partly for the reason already named, that its force was originally determined by getting the largest number of men together to whom one man can issue personal orders by word of mouth—called in infantry the "tactical unit," or unit of manœuvre. The expression is often used, and it is therefore, perhaps, better to mention it here, but the name is a singularly unpractical one, for each portion of an army needs to be a unit, so far as complete harmony of action is concerned, yet in each portion there must be many subordinate parts, each in its degree independent.

Lines of "quarter-columns" are often formed. These are so arranged that the leading company of each battalion is in line, and that the different columns are either thirty paces apart, or at such distance that there is just room between each two quarter-columns for the column to "deploy into line" (that is to say, to form line on its leading company, fronting in the same direction as that in which the column fronts), or the line of columns may be so formed that the columns are at any intermediate distance apart greater than thirty paces, and less than deploying intervals.

Since our object when moving in column is always to be able readily to form line, it follows that in the columns formed of great bodies of troops care must be taken that space is left sufficient to allow of the line being formed with the proper intervals between battalions. Hence, when a large body of troops is moved in columns of companies, it is necessary that space should be allowed between each two battalions sufficient for the leading company of each battalion to be wheeled on its pivot, leaving room in addition for the interval of thirty paces between battalions.

Similarly, in what is called a "mass of quarter-columns"—that is to say, in a column so formed of quarter-columns that the column can become a line of quarter-columns by each quarter-column wheeling to the proper flank—it is necessary that there should be between each two columns a distance equal to the front of the leading company of the battalion following, and thirty yards. This is easily seen on comparing Figs. 10 and 11 in the annexed diagram.



It ought to be noticed, before leaving this part of the infantry drill, that in order to resist cavalry, "squares" are formed in which sometimes the ranks are two deep and sometimes four deep. It is not indispensable to form square on all occasions to receive cavalry now that firearms are so deadly. On the contrary, under ordinary circumstances, where the ground is open and the cavalry can be seen beforehand, they can be repelled by infantry in whatever formation they may be. But the danger to which infantry is exposed by the attack of cavalry is, that the latter by its greater rapidity may work round the flank and come down on the rear of the infantry. Hence, if infantry is caught unexpectedly by cavalry, it is obliged to assume a formation in which it can resist attack from whatever direction it may come. It is no longer necessary, as it used to be, that the squares formed should be always large. They are often of much smaller bodies than they formerly were. To this subject, however, it will be necessary to recur in speaking of the form of fighting which has now become almost inevitably the normal one, and the preparation for which can scarcely in strictness be called drill. This form is that known as skirmishing. In order to make clear the distinction between the nature of the past and of the present, it will be better, however, before speaking of skirmishing, to go through the broad points of the drill of the other two arms.

FARMING AND FARMING ECONOMY.—XX.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

SHEEP (*continued from Page 239*).

CHEVIOT sheep may be described in general terms as a white-faced, middle-woolled race; the males horned and the females hornless; adapted for the severe climate of the Cheviot Hills and for the lower slopes of the Highland mountains, wherever grass does not give way to heather. An attempt was made by Sir John Sinclair to supplant the Cheviot by means of Southdowns, but the climate was too severe for the hardy little south country breed. Cheviots, too, have been introduced into the true home of the Scotch Black Faces, but although successful during ordinary seasons, a severe winter upon those high-lying and exposed lands proved to be too much for them. Crossed with Leicesters the Cheviot sheep form a most invaluable breed, which occupies a large portion of the border counties. When purely bred, the Cheviot sheep is not fatted the first winter, but is reserved to be finished upon grass at eighteen months old, or is carried again on to turnips, and made ready for the butcher at two years old.

The Scotch Black-Faced sheep is sufficiently hardy for the most exposed Highland runs. It is a long and somewhat hairy woolled sheep, although a good specimen should be free from "kemps" or grey hairs in the fleece. The head, which always gives the character to every kind of domestic animal, is black and white, the "paintings" or markings of these two colours being, in the best examples, distinct and not running into each other. The horns are finely convoluted, and spring from the forehead, passing backwards before turning, in exactly the same plane with the forehead. The space between the horns and on the back of the head is covered with fine hair rather than wool. The Black Faces are found on the moors of Yorkshire and the more northern English counties, but are too restless for confinement in arable and fenced districts.

Such are the principal British breeds of sheep. There are, however, two or three others which deserve a passing notice as peculiarly adapted for certain localities. Among these the Herdwicks of Westmoreland and Cumberland occupy a place. These sheep are said to have found their way on to shore from a ship wrecked near the coast, and bear a striking resemblance to a Welsh breed, from which they are probably an offshoot. The Herdwick was soon found to possess valuable properties fitting it for its new home. An association was formed for improving the breed, and annual shows were founded for encouraging the best type.

The Herdwicks occupy the high mountain region of Langdale Pikes, Scaufell, Wasdale, and Hornster Crag. Their appearance is singular. The rams are horned, while the ewes are hornless; the face and legs mottled; the wool somewhat coarse, and longer and darker in colour round the neck, giving the idea of a mane. They clip from 5 to 6 pounds of unwashed wool, which sells for about 8d. per pound (July, 1869). The Herdwicks come to maturity at four years old, when they weigh from fourteen pounds per quarter of mutton of high quality. The usual lambing season extends from mid-April to mid-May. The lambs are brought from the hills at Martinmas, and are placed on lower ground, returning to the hills in April. They are sold when about four years old, at Cockermouth and Keswick fairs, to the lowland farmers, who fatten them on turnips.

SOUTHDOWN SHEEP FROM THE FLOCK OF MR. JONAS WEBB.

The Lonks are peculiar to East Lancashire and West Yorkshire. They, together with the Crag and Limestone breed, are useful upon two classes of land, the one low-lying and moory, the proper habitat of the Lonks, and the other adapted for the dry and high-lying mountain limestone moors. The first breed can withstand the effects of damp, the second can do almost without water. They are therefore exceedingly useful in two opposite conditions of soil and climate occurring within a very short distance of each other. The Lonks are black and white faced, horned and moderately woolled; the Crag or Limestone sheep are white-faced and horned. Specimens of Crag sheep, exhibited by Mr. Rowland Parker of Moors End, Pourton, Westmoreland, at the Manchester Exhibition, 1869, were thus described by the present writer:—Both sexes horned; face and legs white; wool firm, intermediate in length, and inclining to the character of short, rather than of long wool. Mr. Parker's flock clip on an average 7 pounds each sheep, and 1s. 3d. per pound has been realised this season (1869). Mr. Parker rears and feeds off his wether lambs entirely on the lower "inland" ground, and raises them to from 18 to 22 pounds per quarter at

twenty months old. The ewe lambs are kept on the "inland" until they are one year old, and then go to the "common" or high ground from May to October. They are again brought down in October and put to the ram. Mr. Parker speaks to the prolific character of the females. Out of fifty-four ewes thirteen produced three lambs each, while the entire fifty-four brought up ninety-six to weaning-time.

MANAGEMENT OF SHEEP.

This subject may be conveniently divided into the breeding, rearing, and fattening of sheep. So much might be written upon these three sections that we confess to a feeling of great difficulty in selecting those points most likely to give a good general idea of what is meant by each. Breeding entails a ewe flock, and we propose to sketch the salient points in the management of this important part of the farm stock, and, following the lamb from birth to the time it is fatted off upon turnips, to give a general view of the three principal branches of sheep management. Sheep-farming may consist of the breeding of lambs to be sold in the autumn to lowland graziers, and this form of husbandry is usually seen on high poor lands, fitted for rearing rather than fattening animals. A second plan is to buy lambs or lean sheep and fatten them, and this is generally carried out upon good land. A third method is to keep ewes, rear lambs, and fatten them at about one year old. This system is in vogue upon the chalk and oolitic ranges, and wherever land is of light texture and fair quality. The disadvantage of keeping a ewe flock upon really good land is, that ewes require to be kept comparatively poor during a considerable portion of the year, a condition which it is difficult to observe upon good land. Consequently, in such situations ewes are liable to be fat during the whole season, and this is neither advisable nor economical. An intermediate plan may, however, be adopted on such good lands by keeping what is called a "flying flock." By this is meant the purchasing of "cull" or old ewes from some good breeder, taking one "crop" of lambs off them, and then fattening the ewes. The lambs are also fatted, so that new faces are brought into the farm every year. This is a plan which, it will be seen, is inconsistent with the idea of improving a flock so as to bring it up to a high standard of merit.

In tracing the history of a ewe flock throughout the year, we shall follow the ordinary Cotteswold practice, endeavouring to point out any differences of importance between it and that of other good sheep districts. The year is best commenced after weaning-time, when the ewe flock may be considered as commencing another definite period. Immediately after weaning the ewes are put on to dry and poor pasture, firstly to dry up their milk, and secondly for the sake of economy. This is done about the middle of May or first week of June; but the exact period varies. The lambs are best weaned when from nine to ten weeks old. The ewes are frequently run over the grass land, being employed to eat down the ley lands bare that are intended for wheat. They are thus kept until within a month of the time that the ram is put among them, when, if necessary, they are placed upon somewhat better keep, so as to freshen them up a little. It is considered that this ensures a better crop (as it is often called) of lambs than if the ewe conceives while in poor condition. This brings us to September or October, according to the system adopted. In the case before us the 25th of September is a very frequent time. The rams are selected with a view to correcting any faults of the flock, and generally of improving it, and one ram is sufficient to impregnate sixty ewes, although a greater number are often allotted to each ram. Ram lambs are occasionally employed, especially in Hampshire Down flocks, but yearling and two-year-old rams are more ordinarily used. The proper age to place a ewe in the flock is eighteen months, or the autumn after she is one year old, and as a general rule she remains in the flock three years, when she becomes a cull. There are advantages in "culling" the ewe flock "close" or keeping it young, as by so doing the cull ewes will fatten more readily at home, or command a higher price if sold for breeding purposes. It is the object of the flock-master to keep his ewe flock young and vigorous, as well as to improve it as a breeding stock. To this end the flock is weeded, not only of old ewes, but of all defective animals, and, as far as possible, a uniformity of type is secured throughout the flock. After the ram is removed, the ewes are run upon old seeds, stubbles, and grass land, until late in the year. No limit of time can indeed be fixed; for, should the weather remain open, ewes will do much better upon such keep than folded upon roots. Severe weather, and especially snow, will, however, frequently compel the farmer to either fold his ewes, or cart turnips and hay to them upon grass, which last method is to be preferred. Some shepherds are in the habit of allowing their ewes a full allowance of turnips or other roots even in the coldest weather, but this seems hardly reasonable when we remember the large proportion of water, then in a frozen condition, which such roots contain. A much better plan is that described by Professor Coleman in the volume of the *Royal Agricultural Society's Journal* for 1865, where he gives an instance of a Hampshire Down flock which was allowed to run on grass during the day, and was folded on pasture at night. The ewes received in the morning and at night an allowance of trough food, consisting of straw and hay chaff, bruised oats, and palm-nut-meal, at a cost of 2¾d. per head per week. Mr. Wilson, of Edington Main, recommends one measure of pulped roots and one measure of chopped straw; and this will be found better than a very liberal and unrestricted measure of frozen turnips.

As lambing time approaches ¼lb. of cake or corn may be added, and the "theaves" or young ewes will receive a little more indulgence than the older portion of the flock. The lambing season commences in the case before us towards the end of February, and on all Cotteswold farms the ewes are lambed down in a comfortable enclosure constructed of thatched hurdles, the enclosed space being well littered with straw and furnished with small pens for the reception of lambing ewes. This is an engrossing part of our subject, and to give a full description of all the difficulties and methods connected with the management of a large ewe flock at this critical part of their history would demand much more space than is allowed us. The utmost vigilance, day and night, is required on the part of the shepherd, as well as considerable obstetric knowledge. Supposing, as is usually the case, that the lamb is safely born, three days will place the ewe out of all danger from inflammatory attacks, and, should the weather be favourable, she and her lamb or lambs may then be turned out during the day-time. In hard weather shelter at night is still desirable, but in ordinary cases, if the ewe has a good supply of milk, the lamb will be able to withstand the rigours of climate with great hardihood. In a fortnight it will begin to seek other nourishment than that supplied by its dam, and very shortly it will take advantage of the "lamb hurdles," which should always be provided, to run forward and browse upon the young shoots of the swedes or turnips. In the management of sheep from birth until they are ten months old, which is about the time that they ought to be ready for the butcher, not an opportunity must be lost of encouraging their rapid growth and development. We would lay especial stress upon the importance of frequent changes of food, of the early use of dry food in the form of cake or corn, of a supply of water, and of careful watching against the attacks of flies, which are apt in the summer to deposit their maggots in the wool of sheep, and thus to cause them serious annoyance. "We must bear in mind," says Mr. Edmonds of Southrop, a member of council of the Royal Agricultural Society and a leading agriculturist, "that if by care and good living we can make 10 or 11 stone weight each of our young sheep some time in January—that is, from ten to eleven months old—we can keep a heavier breeding flock, and by that means make more mutton and grow more wool than we could if by less liberal living we were unable to dispose of them before March or April, or, as is the case in many instances, even later. Now, how are we to attain so desirable an end? I believe only in this way—by not only preventing our lambs from losing flesh, but by doing our utmost to make them gain flesh, from the very moment they leave their mothers. . . . . Even for two or three weeks before they are weaned, I would recommend a small quantity of pea-meal or oil-cake dust to be given, just to use them to it; then, as soon as they are weaned, two ounces of cake or split peas each (I prefer oil-cake). From that time until August their other food will consist of grass, vetches, and latter-math clover—two kinds of food are best; then rape and vetches, or rape, until the time comes for them to be cautiously put on to turnips. Towards the end of August, or even before, unless the weather is very hot, I would add to the other food a

quarter of a pound of cracked beans each, and, as the season advances, increase by degrees the oil-cake until it reaches ¾lb. each, if straw-chaff be given, but if a fair proportion of good hay, I think ½lb. would be ample. By such living, sheep may be brought to good weights, fat, yet with plenty of flesh, at eleven if not at ten months old, without forcing so as to produce disease, and without extravagant living."

PHOTOGRAPHY.—XIII.

By J. C. Leake.

LANDSCAPE WORK.

In a previous article we have described the dry-plate processes most frequently employed in the production of pictures at a distance from the photographic laboratory; but although these are generally tolerably certain in the hands of a skilled operator, there can be no question that for absolute certainty of result the wet collodion process we have already described is to be preferred. The great advantage of employing the last-named process is that the plates can be developed on the spot, and that consequently, in case of failure, another plate can be exposed without delay, and a picture at once secured. All who have worked with dry plates will readily admit that one of the most tiresome and annoying circumstances attendant upon their employment is the failure of a plate which has been exposed to a subject which the operator has been most anxious to secure, and which in many cases cannot be again attempted. This is the most serious drawback to all dry processes, and therefore, where it is necessary to secure pictures with absolute certainty, the wet collodion process is the only one to be employed.

The great difficulty in the employment of the wet collodion process away from home is the weight and cumbrousness of the apparatus required. Of course a dark room is necessary, in which the plates may be prepared and developed, and this, with the camera and the requisite chemicals, will, where the plates are of anything like large dimension, involve the carrying of an amount of luggage which will in travelling become a burden. In this matter, however, there is no option, and the choice must be made by the operator between the dry plate and its uncertainty, and the wet with its attendant inconvenience and additional labour. Happily, the makers of photographic instruments have bestowed considerable labour and have displayed much skill in the construction of apparatus of a light and portable character for out-door work, and hence the necessary appliances are now not nearly so heavy and cumbersome as heretofore. One word of caution is, however, necessary at the outset, namely, that the operator should, in the purchase of instruments for out-door work, be careful not to sacrifice practical utility for the sake of lightness and portability. Working at home, any little defect of apparatus may be speedily remedied, but in the field everything must be in first-rate order, or some trifling mishap may spoil a day's work. It ought also to be understood at the outset, that in case pictures the size of which exceeds six by five inches are required, the apparatus will be too heavy for one person to carry any considerable distance. Photographing out of doors is hard work at the best of times, and requires that the operator be fresh and vigorous, and it will be found that carrying a heavy package of chemicals and apparatus for a long distance will entirely incapacitate him for the somewhat arduous labours of the day. If such an arrangement can be made, two persons at least should work together, as the operator will need assistance while in the tent. If a horse and cart of some sort can be procured it will save much labour and time, and the additional expense will be amply repaid, both by the ease and comfort with which the work is executed, and by the extra number of pictures which can be made in the time.

Having made these general observations upon the apparatus, it will not be necessary to enter upon further detail in this matter. The operator will find it to be the better plan to consult some well-known maker, who will advise him as to that which will be most suitable to his wants. We may, therefore, at once pass on to the practical details of the work.

Before any attempt at out-door work is made, the whole of the apparatus should be thoroughly tested, in order to ascertain that it is in efficient working order. This may be best effected as follows:—The tent should be set up *in the sun*, in order to test its imperviousness to light. This is most important, as it frequently happens that some small crevice is left through which enough light will pass to fog the sensitive plate. In the tent should be placed the bath with dipper, a broad camel's-hair brush for dusting the plate, the box with the clean plates, and the bottle of collodion. The iron developer and the pyrogallic acid solution for intensifying, with their respective developing glasses, and a sufficient supply of water, should also be provided. The fixing solution of cyanide of potassium need not be placed in the tent, as, after the developer has been thoroughly washed off, the fixing operation may be performed out of doors, although it is better not to expose the plate to the direct action of sunlight. The camera should now be secured to the stand, set up (also in sunlight, for the reason given above), and directed to some suitable object. A plate should now be coated with collodion in the tent, and sensitised in the usual manner. As in landscape work, the plates are usually kept much longer between the sensitising and development than when working in a studio. The utmost care should be exercised in thoroughly draining the plate from the bath solution, or stains will result. A few sheets of blotting-paper should be laid so as to allow of the plate being set up and drained on it, and the back must also be dried by the same means. The plate may now be removed to the slide, and exposed in the usual manner. Of course, during this process the utmost care must be taken to exclude every ray of white light. The curtain which enfolds the operator must be most closely drawn before the plate is immersed in the nitrate bath, and must not be loosened until the door of the dark slide is closed and fastened. After the exposure the plate must be removed to the tent for development, which is effected in the usual manner, exercising the same care in the exclusion of light as during the sensitising process.

It will now be seen whether the apparatus is in good working order. If the plate develops cleanly, and the image is bright and free from fog, this is doubtless the case; but if, as often occurs at first, the plate is fogged and misty, in all probability the light finds admission somewhere, either in the camera or tent. In order to detect the cause and find the source of this, the following course will be best. First, remove the bath and chemicals to the ordinary dark room, and in order to thoroughly test them, take a picture in the usual way. If this is successful, the chemicals are in good order, and the defect is to be sought for and found in the apparatus. The chemicals must therefore be replaced in the tent, and a plate prepared as before, the whole structure having been previously examined for any crevice or orifice through which the light might find admittance. When excited, the plate should be placed in the dark-slide, as if for exposure in the camera. The shutter should now be drawn about half-way up, and a portion of the plate exposed in the tent, as near the window as possible, for four or five minutes. If, upon development, any trace of the shutter is visible, the exposed part of the plate having become darkened, the yellow calico or glass is not sufficiently impervious to light, and must be strengthened by one or two additional folds of yellow calico or paper. Should the plate keep quite bright, however, the defect will most likely be found in the camera.

A plate should be prepared as before and placed in the camera, as if for exposure, except that the cap is not to be removed from the lens. The slide should be drawn up, and the plate left for three or four minutes. If this be fogged, the light finds its way through some aperture, which must be found and stopped. It sometimes happens that when lenses of large aperture are used out of doors the light flares on their surface and causes fogging. These should, therefore, always be shaded, by holding a board or shade over them during the exposure of the plate. Having thus ensured the efficiency of the apparatus, the necessary preparations may be made for actual work; but we should advise the operator to devote at least one day to tent work before attempting to operate out of doors, in order that he may become accustomed to the different conditions under which he will have to labour.

In order to produce good work the utmost care must be taken to provide, before starting, a proper supply of chemicals, and also to do everything that can be done in the way of cleaning plates, etc., so that, upon arrival at the scene of operation, the actual work of taking pictures may be entered upon at once. We will suppose the operator to intend working upon plates of ten inches by eight, and will give an estimate of what will be required for one day's work. Of course, the tent and camera,

with their respective stands and the required screws and fittings, will be the first necessities; and these, cleaned and dusted, together with the lens, may be packed first; next will come the glasses, which should be of patent plate, most carefully cleaned and packed in boxes. It is a good plan to have two boxes, one for clean plates and one for negatives—the latter should be of metal, if possible. As a rule, twelve or fifteen plates will make an ordinary day's work. The silver bath should be one of glass or ebonite, of water-tight construction, so as to avoid carrying an extra bottle for the solution, and an ebonite dipper should be used in case of breakage. This, with a brush, and the glasses used for development, will nearly complete the list of apparatus required. The chemicals will be collodion (say ten ounces), in two separate bottles, in case of accident to one of them; iron developing solution (ten grains to each ounce), twenty ounces; pyrogallic acid solution (three grains), ten ounces. The fixing solution may be made on the spot; a bottle containing cyanide in a dry state should therefore be taken, and a separate bottle for mixing it in as required. A suitable vessel should be provided for taking water; and it is a good plan to carry a ball of string, which may be useful in securing the tent, should the wind be troublesome. A couple of coarse cloths, a towel, and a piece of soap should also be provided, as the bottom of the tent should be wiped out after the preparation of every plate, and the hands thoroughly cleansed and dried. A good supply of blotting-paper should also be taken, for the purpose of draining the plates. If a box can be obtained, having a separate compartment for each of these things, it will be most convenient, as it can then at a glance be told whether or not the equipment is complete. As an additional precaution, a written list should be pasted upon the lid of the box, so that each article may be called over before starting. It may seem that these precautions are unnecessary, but it must be remembered that one item being short the trip will be useless.

Upon arrival at the proposed place of work, a convenient place should be chosen upon which the tent may be erected. It is as well to thoroughly examine the ground before setting up the tent, as it often happens that several pictures may be taken within a reasonable distance, and it is better to have the tent in as central a spot as possible. A shady corner should be selected for the sake of coolness. The bath and chemicals should then be placed in the tent in readiness, and allowed to rest for half an hour, if possible. In this interval the camera may be prepared and focussed, and it will be well to select several views before commencing to operate. Frequently very much more effective pictures may be taken of a scene at one time of the day than at another; this should be taken into account, and arrangements made accordingly. A plate may now be prepared, and a picture taken precisely as has been already described.

In places where water is scarce the pictures need not be fixed in the field, although this is undoubtedly the safest plan where practicable. In this case, after the intensifying solution has been applied, and the plate thoroughly washed, the following solution should be applied:—Glycerine, half an ounce; water, two ounces. The plate should be thoroughly flooded with this, and placed in a metal box. Upon arrival at home the plate should be well washed, fixed, and varnished in the usual manner. Great care will be required, however, in washing, in order to prevent the film from slipping off the glass. Some care is also required in placing a wet plate in the box, or the film will catch in the grooves and become torn. The best plan is to carefully remove the film for the space of a quarter of an inch on each of the sides which have to be placed in the grooves. This will prevent the catching and tearing of the film.

From the foregoing remarks it will be seen that landscape photography is somewhat more difficult, and requires more practice, than those branches which may be executed in-doors. The chief difficulty at first will be found in working in the very circumscribed space afforded by the tent. This, however, is speedily overcome by practice, and if care is taken that each operation is performed cleanly and with neatness, it will be found as easy to work in a tent as in the well-appointed laboratory at home. Two things chiefly are needful to ensure success—namely, that the work be executed without hurry, and with the utmost precaution as to cleanliness in every detail. Both of these are indeed necessary when working in the ordinary dark room, but in the heat of the tent the result of inattention to these particulars is certain and inevitable failure.

HOROLOGY.—II.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

WATCHES: THEIR PRINCIPLE OF CONSTRUCTION.

Construction, in its general sense, implies design and arrangement, and in its application the harmonious adjustment of all the forces in question. Although in horology there are not so many forces to deal with as in mechanical and civil engineering, its difficulties are nevertheless considerable. The watchmaker has to guard against waste of motive force by resolution, or, in other words, against undue pressure and friction, by which the mainspring force is working the destruction of the watch; and he has to control or neutralise every force by which 432,000 distinct and separate movements, performed by an instrument in twenty-four hours, may be increased or diminished by a single one.

In horological construction there are some prominent and definite points, to which all others bear a secondary but fixed relation. The great problem to be solved by horology may be simply defined as the relation of motion to time, in which the balance vibration within a given period forms the unknown quantity to be determined. The balance is made either of steel, gold, or partly of brass and partly of steel. It is circular in shape, and mounted on an axle called the staff, whose ends or pivots run in fixed holes made of garnet, sapphire, or ruby. Attached to this staff, above or below the balance, is a spiral coiled spring, much resembling in shape the mainspring, concentrically fixed, its inmost coil running through and bent round into the hole of a collet or small collar placed over the staff. The outer end of this spring runs through and is fixed into the hole of a stud screwed firmly to a rigid part of the watch.

This spring, called the pendulum or balance spring, does the same office to the balance as gravitation to the pendulum. If the balance is moved to the right or left, the spring is inflected or bent either outward or inward. The inflection of each coil depends on its distance from the centre of motion or balance pivots, the length of the spring as a whole, and the radius of the orbit of its innermost coil, or size of the collar or collet to which it is fastened; and according to the angle of inflection, so will its resistance or accumulated elastic force be. If now the balance be released, the force of the pendulum spring will give it motion, which accelerates its velocity until the balance has passed the point where the spring is in poise. But the conditions are reversed the moment this point is passed. The balance momentum has now to bend the spring afresh, the resistance of which progressively increases until both are *in equilibrio*, and the balance stops. This stop is of momentary duration; the momentum of the balance being now expended, the resistance of the spring becomes again the accelerating force, and another vibration is performed, and so on. A vibration is therefore a single and distinct motion of the balance acted on by the balance or pendulum spring, which commences at and finishes with a stop, and the duration of which depends upon the ratio of balance, momentum, and strength of spring. The balance varies in watches, being designed to make from 240 to 300 vibrations per second, or 14,400 to 18,000 per hour. The correct performance of a watch depends on the balance making the vibration it is designed to make in a given period; the hands merely register them, and will move faster or slower, as the balance vibrations are above or below the proper number.

So far we have simply considered the balance vibrations in their relation to time, assuming they are kept up, which keeping up or continued reaction is, however, not a spontaneous act of the balance. If we take a lever watch, not wound up (with a chronometer or duplex this experiment is not advisable), and by a shake or twist of the case set the balance in motion, we find that each vibration is a little shorter than the preceding one, until the last has died off. This gradual cessation is caused by and proportioned to the amount of balance momentum expended in overcoming resistance; and, therefore, to keep the balance in motion, we have to impart a continued fresh supply of momentum, such fresh supply being given by the contrivance called the escapement. As it is the uniformity of the duration of the vibrations that is the element of true time, it is obvious that they should be as free as possible. It is the relation existing between the escapement and the balance, the more or

less perturbing influence of the former on the latter, that establishes the merit of the various escapements, and according to which they stand in the following order, namely:—

1. Chronometer.	3. Duplex.
2. Lever.	4. Horizontal.

The lever escapement, being the most popular, will receive our attention first. The four escapements are ranged in two classes, namely:—

1. Detached, comprising the Chronometer and Lever.
2. Undetached, comprising the Duplex and Horizontal.

It may be as well to state here that there is yet another escapement in use—namely, the verge, which, by reason of its inferiority and impracticability for watches of modern requirement, we have not thought needful or desirable to write upon. The difference between detached and undetached escapements consists in the mechanism by which the force in the escapement is completely locked off during the interval from one impulse to the other, and during which the arc of vibration is free.

In the second class the escape-wheel presses continually against the staff in the duplex, or cylinder of the horizontal, under which pressure the vibration takes place, and has a very perturbing effect. A source of evil in the detached escapement is the contrivance by which the latent force in the escapement is relieved or unlocked. This is effected by the balance at the expense of its momentum, and proportioned to the amount of force to effect such unlocking. The undetached escapements are free from this error, as the escape-wheel is constantly pressing on the staff or cylinder; it is relieved instantly when they are in position to receive impulse.

The mode in which impulse is imparted is a general source of error. If we divide the arc of impulse—that is, the angle the balance passes through—into degrees or minutes, the perfect impulse would be that which would vary in direction with every minute, and would constantly represent the tangent to the radius of contact, and in proportion as it deviates from this it causes more or less error by resistance of rubbing-surface.

With these general outlines of the escapement, which are to be filled in more by-and-by, we will pass on to trace its connection with the remaining part of the watch.

The wheel adjacent to and in connection with the escape-pinion* is the fourth or seconds-wheel, called so because its pinion carries the seconds-hand upon a long pivot extending through the dial, and turns about its own centre once every minute. The escape-wheel of modern watches has mostly fifteen teeth, each tooth giving two vibrations, or equivalent to two, which is equal to thirty vibrations, often called "beats" by watchmakers. A watch going at the rate of 18,000 vibrations per hour will make per minute $18{,}000 \div 60 = 300$, and rotations† of the escape-wheel $= 300 \div 30 = 10$ per minute; that is to say, the escape-wheel has to turn ten times on its own centre while the seconds or fourth wheel rotates once. This wheel being geared or pitched into the escape-pinion, in order to get this result the number of teeth in the wheel must be to the number of leaves in the pinion as the number of rotations of the escape-wheel is to that of the fourth wheel; that is, if we give the escape-pinion 7 leaves, and put the number of fourth or seconds teeth at x, then—

$$1 : 10 :: 7 : x,$$
$$x = 10 \times 7 = 70 = \text{the number of teeth.}$$

Going further back, we come to the relative rotations of the seconds or fourth and centre wheel, the former making sixty rotations to one of the latter. Between these two, which are connected by it, is the third wheel. Whatever number of teeth and leaves we give these wheels and pinions, in order that the seconds-wheel may rotate 60 times to 1 of the centre, their ratio must be such that the product of the centre and third wheel teeth is to the product of the third and seconds pinion leaves as 60 is to 1. If we give the third and fourth pinions eight leaves, the third wheel sixty, and centre wheel x, then—

$$1 : 60 :: (8 \times 8) : (60x);$$
$$60x = \frac{60 \times 64}{1} = 3840.$$
$$\therefore\ x = \frac{3840}{60} = 64 = \text{number of centre wheel teeth.}$$

This brings us to the last section of the train of watch-wheels.

Watches are generally designed to go from twenty-eight to thirty-two hours at one winding. For our illustration we will take a case at thirty-two hours, allowing six to eight hours surplus should the winding of the watch, through any occurrence, be delayed. The fusee, or toothed barrel, technically called the going-barrel, has therefore to turn the wheel adjacent to the centre wheel thirty-two times about its centre.

The fusee or going-barrel is, with very few exceptions, made to make four rotations to one winding, or thirty-two hours, and the centre wheel has therefore to make eight rotations to one of the fusee. The conditions of number of the respective wheels and pinions is therefore a mere repetition of the first one given; that is, the number of teeth of the driving-wheel is to the number of leaves in the pinion as the number of the rotations of the centre wheel is to that of the driving-wheel; or taking the centre pinion at 10 and driving-wheel at x, then—

$$1 : 8 :: 10 : x;$$
$$x = 10 \times 8 = 80 = \text{number of teeth in driving-wheel.}$$

Hence the watch goes eight hours for each turn of the fusee, or thirty-two hours at one winding.

Reviewing the whole, we notice four distinct cardinal sections—viz., the balance, escapement, train, and mainspring. Of these the first is the prime mover, the second a reservoir of impulsive force, the third the channel of supply, and the fourth the source of force. As it is desirable to have the impulse dealt out to the balance with as little perturbance as possible, it follows that the motive force should be transmitted to the escapement as regularly as possible; or, in other words, the force generated in the mainspring should be so economised that approximately the centrifugal force of the fusee may be to that of the escape-wheel as the velocity of the latter to that of the former, such economy depending on the watch being constructed in such a manner that no force is expended in overcoming undue resistance by erroneous contact. As such errors arise through imperfect gearing or pitching, we will add a few words on this subject.

By gearing, pitching, or a depth, is meant the relative position of a wheel and pinion in such a manner that all motion imparted to one wheel will communicate itself to the other in an inverse ratio to the number of their respective teeth. Supposing we place a wheel and pinion into the depthing tool, with sixty-four teeth and eight leaves respectively, the latter will make eight rotations to one of the first. If we now replace them by two discs in such a manner that they touch at their circumference, and communicate motion in the same ratio as the wheel and pinion so replaced, we shall find that when this condition of their motion is obtained their diameters are in the same ratio as the number of the teeth and leaves of the pinion. Such contact may be sufficient to communicate motion, but there is no certainty, neither is it possible to transmit force; hence the contrivance by which such two discs shall rotate in ratio to their diameters.

This contrivance consists in projections and recesses in both discs, so as to dip alternately into one another. The projections are in addition to the circle of the same diameter as the disc, which is called the primitive or pitch-circle, and the indentures, recesses, or spaces are in subtraction of the circle of the diameter of the disc, or within the pitch-circle. We have, therefore, a pitch-circle in every wheel and pinion, and these circles of a wheel and pinion forming a depth should be in exact ratio of their respective numbers, and in relation as the discs described.

The shape of the sides of such wheel-toothing is, or should be, formed by sections of the epicycloid, the curve being traced from either side of the tooth, the point of bisection being the termination of the toothing. (See "Technical Drawing," Vol. II., page 12.) The same can also be accomplished by co-ordinates. These methods and their elucidation belong to the

* A pinion is a piece of steel the circumference of which is regularly divided, and indentures cut into it to two-thirds of the radius from circumference, leaving six, eight, ten, or more projections called "leaves."

† There is considerable misconception about the terms *rotation* and *revolution*. The first means a wheel turning about its own centre, and the second about a borrowed centre. So, in the tourbillon, the escape-wheel rotates about its pivots, but revolves about the pivots of the tourbillon. Again, the earth rotates about its axis, but revolves around the sun.

province of the mathematician, and are beyond the limits of these papers. But in order that the practical workman, who may peruse these pages, may gather some idea of the epicycloidal curve, I suggest the following experiment in solid material:—Take a brass disc, describe a circle, which is to represent the pitch-circle, and mark off the breadth of a tooth. Prepare two discs, one the size of the circle described and fixed to it, and the other approximating on the ratio of a pinion of six, and fix a fine point in the circumference of the latter. Place them in the depthing tool in the following manner:—Let the discs touch one another, so as to communicate motion; let the point in the circumference and the side of the tooth be in a straight line between and parallel to the centre of the depthing tool, and let the point in the disc touch the wheel upon which the curve is to be traced. Moving now both discs together, a curve will be traced, which is a section of the epicycloid. If the same operation is repeated and reversed from the opposite side of the tooth, the epicycloidal toothing is traced out.

Be this curve mechanically or mathematically traced out, the condition of the toothing depends upon the ratio of the generating and primitive circles, for, as their difference diminishes, the altitude or height of the toothing traced increases. Considering the heterogeneous conditions of depths with various numbered pinions, we come upon the question: What is the proper or best ratio between the primitive and generating circles to obtain curves approximately suited to these various conditions? This, of course, cannot be discussed here, nor the question of contriving the production of a tooth in solid material answering in any number of repetitions to its duplicate. It must suffice to hint at one or two facts arising out of these conditions.

Going back for a moment to the discs or primitive circles for an illustration, and drawing a line from the centre of one to the centre of the other, which line is called the line of centres, we find that this line bisects or cuts the two circles in the point or place where they touch each other, and that at either side of this line the circles recede progressively from each other.

Consider a pinion of six leaves in the light of a circle, that circle being divided into six equal parts, the angle formed by the faces of two leaves is equal to 60°.

If we now measure off on our smaller circle an angle of 60° with the line of centres, and draw a line from the point thus measured off to the centre, the line thus drawn and the line of centres will represent the faces of two leaves of a pinion of six; and supposing that the contact of a tooth of the wheel and a leaf of the pinion commences in or at the line of centres, with a pinion of six leaves, such contact having to continue through a movement of 60°, we have further the altitude or height of the toothing indicated by the distance of the point measured off in the minor circle from the major circle. In a wheel and pinion the motion is communicated from the former to the latter by contact of the face of a leaf with the tooth, the latter pushing the other before it, until, by reason of the rotary and receding motion of the face of the pinion, the contact ceases, such cessation depending entirely, whether it be at an angle of more or less than 60°, on the altitude or height of the tooth; from which we gather that, as the pinion movement must be at a fixed angle of 60°, just as much as the contact of tooth and leaf passes through an angle of more or less than 60° past the line of centres, so also must the contact commence before or after the line of centres. Here we come upon the question as to how far it is practicable that the action should commence before the line of centres, the discussion of which must also be left, with the exception of one or two points.

The greatest amount of centrifugal force is communicated to a pinion by contact past the line of centre, when the former forms a maximum angle with the latter, because they assume the conditions of levers and inclined planes. On the other hand, if the contact takes place considerably before the line of centres, the whole force of the wheel is expended in pressure; hence all rotary motion ceases, and consequently the watch stops. In fact, in ninety-nine cases out of one hundred where a watch stops in a depth, it is because of the action commencing too soon. We have, therefore, two extreme limits of the greatest and least force transmitted, and in proportion as the action or contact takes place between these points we have economy or waste of mainspring power.

If a pinion is applied larger than the described ratio, the result is that the chord of two leaves of the pinion is greater than one of two teeth of the wheel; and hence, in such a depth, we get action before the line of centres, which, in proportion, will cause a stopping of the watch or some other irregularity. On the other hand, no small-sized pinion, provided the depth is not too shallow and that there is sufficient clearing, will ever cause a stoppage, because the action cannot commence before the line of centres.

In planting a depth it is necessary to ascertain the proper proportion of the wheel and pinion to be geared, because when the pinion is larger or smaller than it ought to be, it falls within or without the pitch-circle of the wheel, as the case may be. For example, if we have a standard depth with a pinion of the right size, and another of a wheel of the same size and number but a larger pinion, the last depth would require to be just as much deeper than the former as the half diameter of its pinion is greater than the other pinion.

The general way to ascertain the size of a pinion is by a sector, but as the counting of teeth and putting in the sector involves much time, I will give here a simple but correct method—namely, count the number of leaves in the pinion to be tried, add 2, and divide by 3, the quotient being the chord of the number of teeth (and, as a consequence, the spaces within them) that the diameter of a right-sized pinion measures.

Example.—In a pinion of seven we have $7 + 2 \div 3 = 3$, or equal to the space occupied by three teeth (and two spaces within), the measure of the diameter of a pinion of seven.

Again, for a pinion of ten, we have $10 + 2 \div 3 = 4$, or equal to the space occupied by four teeth (and three spaces within), the measurement of the diameter of a pinion of ten leaves. In this method it is assumed that the teeth and the spaces are equal; hence, where they are not, allowances must be made.

It will scarcely be necessary to observe that pivots should be as small as stability will permit, and as well glossed as possible, because the amount of resistance from or in the pivots is measured by the product of rubbing-surface and its radius; hence thick and rough pivots offer greater resistance than smooth and thin ones.

We gather, therefore, from the foregoing remarks that the balance requires a certain amount of impulse-force, which must be supplied to overcome the local resistance; that each wheel must give off to the preceding wheel as much force as that one again has to supply to the next, *plus* the force to overcome its resistance both of pivots and depth; and hence, in proportion as force is absorbed in its transmission through the train to overcome local resistance, so is there an excess of mainspring power required; and as, mechanically, no force is absolutely lost, this excess of force is working the destruction of the instrument. According to this, common and badly constructed watches require stronger mainsprings than good ones, and hence more frequent repairing.

Horological construction means, therefore, the formation of parts and their relative adjustment according to laws that govern them, so that all forces involved act harmoniously toward one and the same end.

The principle of construction is, therefore, not exhausted until the last piece of a watch has been described, and hence what has been said is more to be accepted as a view of the whole. A spectator standing on a hill surveying a landscape, will have an idea of the relation of each single object to the whole when he comes to examine it separately. In the same sense, I hope I have succeeded in making clear to the reader the relative office of these sections to the correct record of the hands on the dial of his watch.

THE LATHE.—XVI.

By Henry Northcott.

LATHES FOR SPECIAL PURPOSES.

The self-acting lathes hitherto given are such as are in general and universal use for the miscellaneous work of engineering workshops. Either of these lathes is capable of producing a great variety of forms, from a small bolt to an excentric, and in every workshop there is enough miscellaneous work to keep one or more of these lathes employed upon it. But when a large number of bolts or excentrics have to be produced—enough to

keep a lathe going—it becomes advisable to have a lathe designed especially for the production of that one article, without reference to its general usefulness. The precise form the special lathe will take depends, of course, upon the motions it is called upon to execute. In some cases the ordinary lathe may need very little, if any, modification beyond the use of tools of a certain shape, and in other cases the lathe mechanism may require to be of a very complicated and peculiar nature. Frequently the chief alteration necessary is in the size. Massive work requires a massive lathe, but very large lathes are seldom made on the same model as those of moderate size. Figs. 104 to 109 illustrate a large lathe made by Messrs. Ducommun and Co., of Mulhouse, and exhibited at the last Paris Exhibition. Of the illustrations, Fig. 104 is a longitudinal elevation; Fig. 105 a plan; Fig. 106 a cross section showing the slide, tool-rests, and face-plate; Fig. 107 is an end elevation of the cone headstock; Fig. 108 an end elevation of the screw headstock; and Fig. 109 a cross section showing the saddle-rest.

This lathe, for the description of which I am indebted to *Engineering*, is designed for turning heavy marine work and heavy guns, and it has sliding and screw-cutting mechanism, with an arrangement for producing true conical surfaces. The lathe-bed, which is cast on the box principle, is about 40 feet long, and 5 feet wide, measured over the V's; the height of the centres is about 3 feet 6 inches, thus admitting an article of about 7 feet diameter. The fixed or cone headstock is double-geared, provided with an internally geared face-plate, and quick return motion direct through the lathe-spindle. The cone-shaft, whose bearings are made to slide horizontally towards and from the centre of the lathe-bed, may be thrown out of gear with the face-plate by means of two set-screws; at the same time a small pinion which it carries is thrown into gear with the wheel on the main spindle, when it is intended to run at quick speed. The intermediate shaft, through which motion is communicated to the face-plate when taking heavy cuts, revolves in excentric bearings, and is thrown out of gear by turning these bearings round upon their own centre by means of a worm and worm-wheel. The tendency of this shaft being to fall back into the position of greatest stability, the worm-wheel should be provided with some kind of stop, to prevent the shaft from being thrown out of gear by the jar of the wheels in motion.

The main spindle rests in cylindrical bearings, and is fitted with a thrust-pin behind, in preference to the conical bearings so largely used in this country. The screwing motion is derived from the lathe-spindle in the ordinary manner, but by means of a very neat arrangement of a lever pivoting upon a stud, and carrying permanently two equal pinions which gear into each other; the reverse motion of the screw for cutting left-hand-threads may be obtained by causing one or other of these pinions to gear into the first of the train of wheels that drive the screw with a slight motion of the lever only, and without the necessity of introducing an intermediate pinion, which has to be removed again. The propriety of fitting a heavy lathe like this with a screw-cutting motion might with some show of reason be called into question, but the screw was introduced chiefly to meet the condition of turning true conical surfaces, a condition imposed upon the maker by the officials in command of the French arsenals.

The longitudinal sliding motion is derived directly from the screw in much the same manner as in smaller lathes, and the slide-rest may be moved by hand along the bed, through a pinion gearing into a rack fixed to the under-side of the top table of the lathe-bed, in which case the nut is disengaged from the screw by means of a worm and worm-quadrant working a system of small levers.

The slide-rest carries two cross slides, each worked by an independent screw, by means of which arrangement two cuts may be taken simultaneously at opposite sides of the work. These cross slides are also moved indirectly by the main screw, through a train of wheels, the first of which is fixed to the end of the former, where it projects through the lathe-bed. Motion is thus given to a shaft which carries a sliding wheel, which drives a worm and worm-wheel, and by means of a small spur-wheel which gears into one of the small pinions carried by the screws of the cross slides, these slides are moved simultaneously either towards or away from the centre of the lathe-bed, as may be necessary.

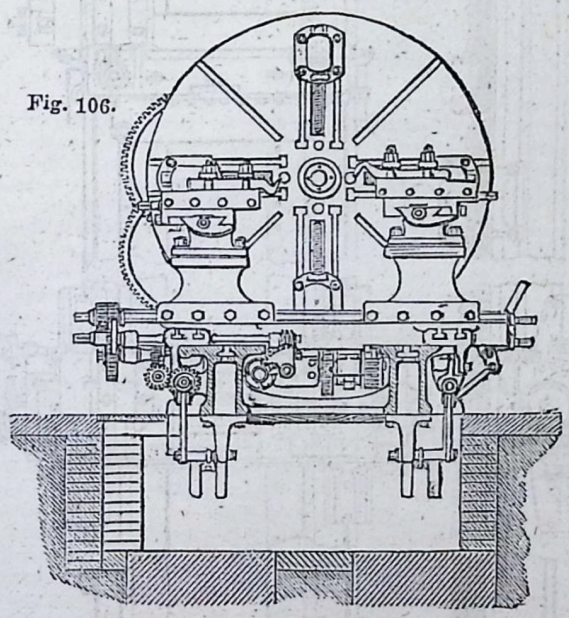


Fig. 106.

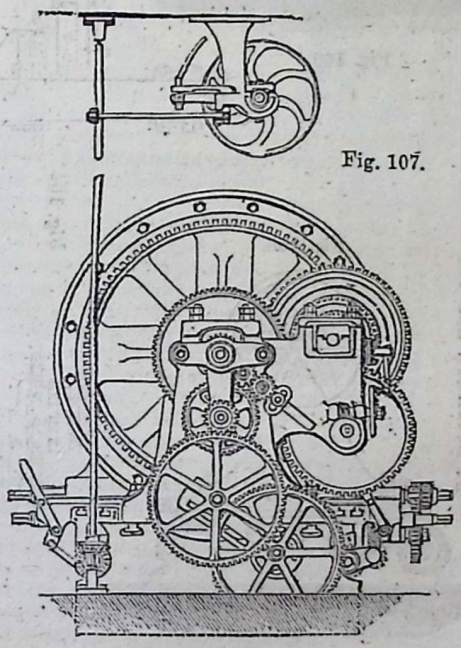
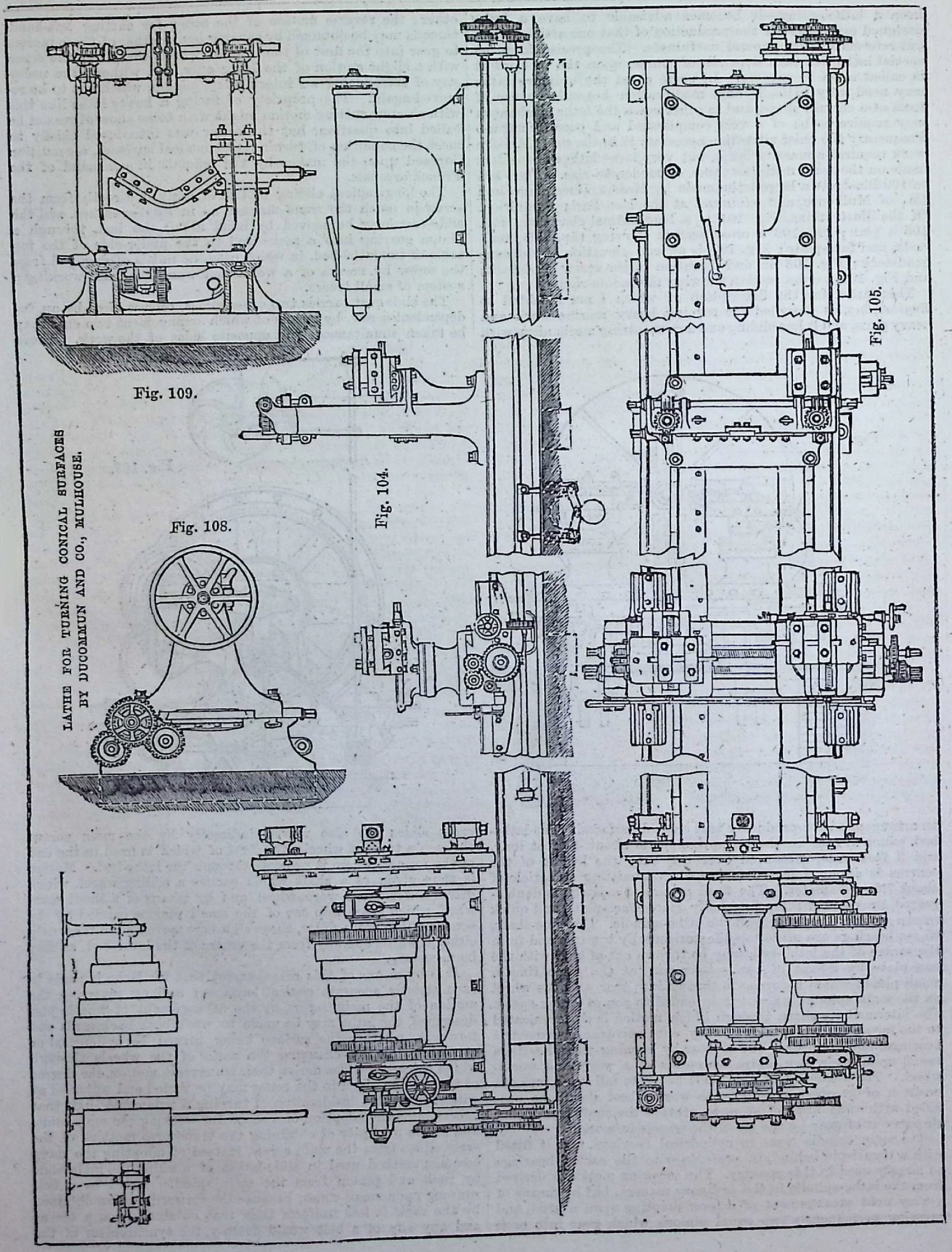


Fig. 107.

It is by means of this arrangement that the lathe is made to turn strictly accurate conical surfaces; and by reversing the motion of the main screw, by the arrangement of wheels just described, the lathe may be made to work both backwards and forwards, whether the surface being turned be cylindrical or conical; while by changing the ratio of the wheels through which the cross slides derive their transverse motion, the degree of taper to be given to the cones may be varied and adjusted at will. It was this desideratum of turning a true conic shaft that necessitated the adoption of a screw for working the main slide, and to the necessity of obtaining the transverse motions of the cross slides from the main screw, instead of adopting the more common method used in slide-lathes of working the main slide by rack and pinion from the main spindle, direct by a belt running upon small cones, because the forward motion obtained by the rack is less uniform than that obtained from a screw, and any slip of a belt would destroy the synchronism of the



LATHE FOR TURNING CONICAL SURFACES BY DUCOMMUN AND CO., MULHOUSE.

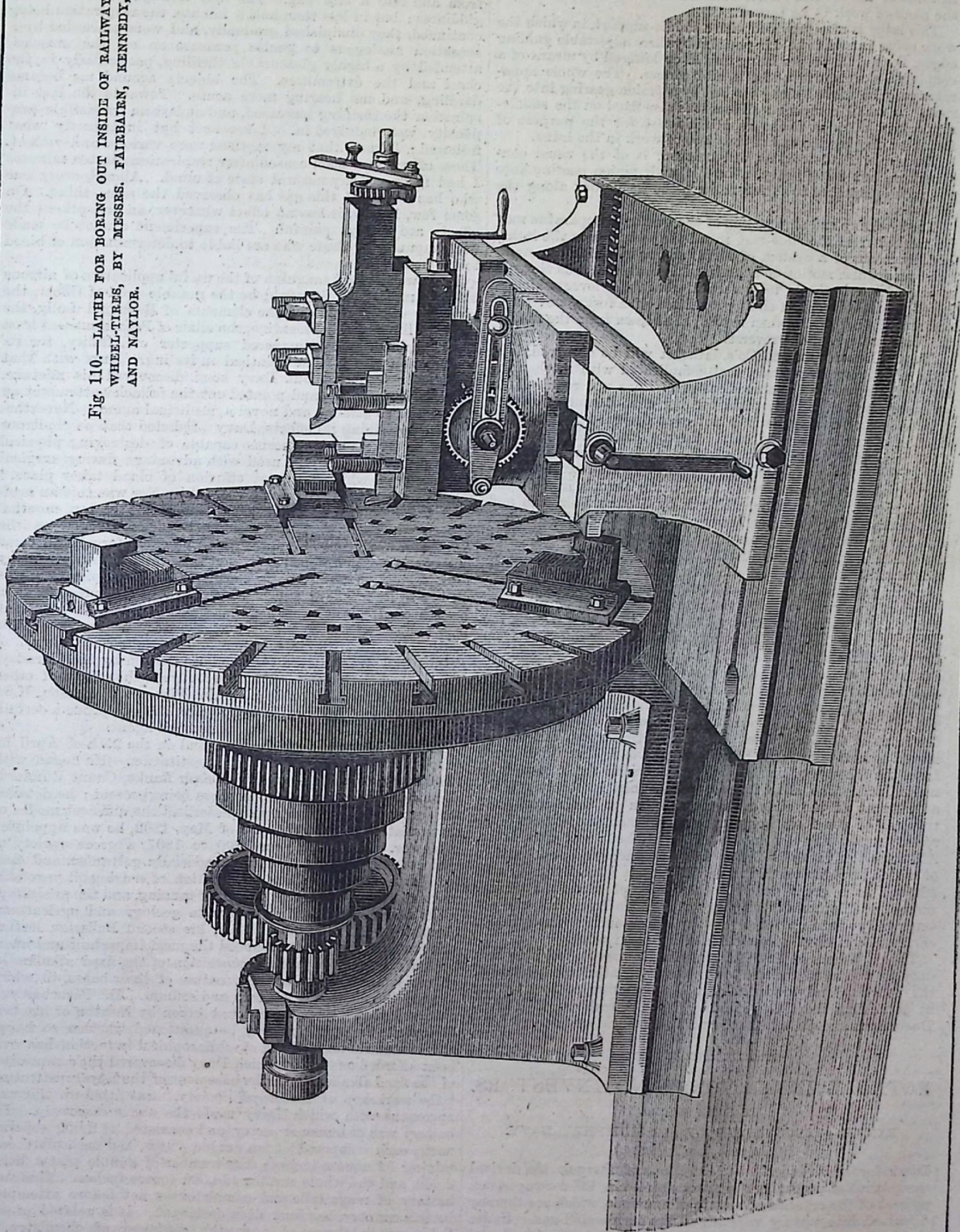


Fig. 110.—LATHE FOR BORING OUT INSIDE OF RAILWAY WHEEL-TIRES, BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

motions of the several slides, with the circumferential speed of the piece of work to be turned.

This lathe is also provided with a saddle-support, in which the work being turned is held in position by three adjustable guiding edges, the saddle proper being raised or lowered by means of a couple of worms, worm-wheels, and screws. The whole apparatus may be moved along the bed by a pinion gearing into the rack. A small compound slide-rest is also fixed on the saddle-support, in addition to the usual slide-rest, for the purpose of facing or shaping the end of the piece of work in the lathe.

The screw headstock, as will be seen, is of the usual construction, but being heavy, a handle with pinion gearing into the rack is attached to it for moving the headstock along the lathe-bed.

The reversing and stop motion of the overhead apparatus may be worked from the slide-rest in all its positions on the lathe-bed, by means of a system of levers and rods, which communicates an angular motion to a horizontal shaft, and this through a pair of bevel wheels to a vertical shaft. A lever which is keyed upon this works a sliding-rod fitted with forks, and these embrace the belts, and when moved, shift them from the fast to the loose pulleys, or the reverse.

Messrs. Ducommun and Co's. lathe, it will be observed, is a lathe on a very large scale, and complicated with mechanism for producing certain combinations of motions not required for ordinary work. Ordinary plain turning can, of course, be performed in such a lathe, as it is not even designed for the production of conical objects only. In the lathe shown at Fig. 110 the speciality is more apparent, as it is designed to effect one object only—namely, to turn or bore out the insides of railway wheel-tires preparatory to their being shrunk in upon the wheel proper. This lathe, which is by Messrs. Fairbairn and Co., consists of an ordinary heavy cone headstock with gearing, and having a very large face-plate upon its spindle-nose. The face-plate is fitted with adjustable gripping jaws, which may be moved either nearer to or farther from the centre of the lathe, according as a smaller or a larger tire has to be chucked. The flange of the tires falls into the undercut grooves of the jaws, whilst the tread is gripped by the three projections. All the other parts of this lathe are arranged altogether different from any yet illustrated. There is no screw headstock, and no substitute for it. The lathe-bed is merely a flat, short plate, and the slide for the two rests is at right angles to its usual position. The two slide-rests, in fact, are carried upon a short bed, which is fastened down upon the main bed-plate, across the front of the face-plate. The small transverse bed can be moved a short way upon the bed-plate, so as to alter its distance from the face-plate, but its parallelism with the face-plate is maintained. The slide formed by the bed is chiefly for the adjustment of the slide-rests in relation to their work, the traverse of the tools being effected through the slides of the rests proper, and by means of a ratchet-wheel and lever. Although this lathe is designed for producing a special article of which large numbers are required, it is almost equally well adapted to a great deal of other work of somewhat similar nature, and lathes differing but very little from this one are employed to turn up large plane surfaces such as the cylinder covers of horizontal steam-engines and other work.

The publishers of THE TECHNICAL EDUCATOR feel it to be a duty as well as a pleasure to express their acknowledgments of the courtesy and kindness of the proprietors of *Engineering* in permitting them to reproduce the illustrations of Messrs. Ducommun and Co.'s lathe for turning conical surfaces.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVII.—DISCOVERIES OF SIR HUMPHRY DAVY.

(*Continued from Page 314.*)

DAVY, for the investigation of the effects of nitrous oxide, devised the method of procuring the nitrous air—viz., the decomposition by heat of the crystals of nitrate of ammonia, which are thereby dissolved into watery vapour and the desiderated gas. Under the famous name of nitrous oxide, he minutely examined and recorded its properties for the first time. In his "Researches," he tells us: "Having previously closed my nostrils and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to giddiness; but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by a highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, and at last an irresistible propensity was indulged in. I recollect but indistinctly what followed; I know that my motions were various and violent. These efforts very soon ceased after respiration; in ten minutes I had recovered my natural state of mind. Almost every one who has breathed this gas has observed the same thing. On some few, indeed, it has no effect whatever, and on others the effects are always painful. The experiment cannot be made with impunity by those who are liable to determination of blood to the head."

Davy was at first sanguine of the useful application of nitrous oxide to medicine. It might be the notable gold of Geber, the vivifying quintessence of the elements of Raymond Lully, the water of life of Basil Valentine, the elixir of Paracelsus—at least some purified and attempered supporter of vitality, for its composition was almost identical in its ingredients with that of the atmosphere. But Davy soon discovered his mistake, recorded its inutility, and pointed out the fallacies attendant on the trial of so strange and novel a medicinal agent. Nevertheless, in describing its effects, Davy predicted that as "nitrous oxide, in its extension, seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." (Davy's "Collective Works," Vol. III.) Nor was this an accidental conjecture of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea, which by chloroform has become one of the most glorious realities of the present century. Davy also foretold that pneumatic chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded, "it is probable that pain would have been put into subjection to the intellect at the very beginning of this century." In 1818, in a paper in the *Quarterly Journal of Science and Art*, believed to have been written by Mr. Faraday, is described the great resemblance between the effects of ether and those of nitrous oxide gas. Dr. Bigelow, of Boston, U.S., also predicted nitrous oxide to be quite likely to prove a certain as well as a safe and agreeable anæsthetic agent.

In 1801 Davy came to London, and on the 25th of April he gave his first lecture at the Royal Institution. He began with the history of galvanism—Sir Joseph Banks, Count Rumford, and other distinguished philosophers being present; he detailed the successive discoveries, and described the different modes of accumulating it. On the 31st of May, 1802, he was appointed Professor. From the year 1800 to 1807, a great variety of subjects attracted his attention, especially galvanism and electro-chemical science; the examination of astringent vegetable matter in connection with the art of tanning, and the analysis of rocks and minerals with relation to geology and agricultural chemistry. In November, 1807, his second Bakerian lecture was read, in which he announced the most important and unexpected discovery of the decomposition of the fixed alkalies by galvanism, and of the metallic nature of their bases, to which he gave the name of potassium and sodium. Dr. Paris has well observed that "since the account given by Newton of his first discoveries in optics, it may be questioned whether so happy and successful an instance of philosophical induction has ever been afforded as that by which Davy discovered the composition of the fixed alkalies." In the basement of the Royal Institution, "the workshop of the Royal Society," was fitted up the vast apparatus with which Davy made the above discovery. The battery was of immense power, and consisted of 2,000 separate parts, each composed of ten double plates, and each plate containing 32 square inches; the number of double plates being 2,000, and the whole surface 128,000 square inches. This vast battery, of magnitude and completeness not before attempted in this country, has long been destroyed. It is related of the ludicrous indolence of a worthy professor of chemistry at Aberdeen, that he had allowed some years to pass over Davy's brilliant discovery of potassium and its congeneric metals with-

out a word about them in his lectures. At length the learned doctor, being pressed by some of his colleagues on the subject, condescended to notice it. "Both potash and soda," said he, "are now allowed to be metallic oxides; the oxides, in fact, of two metals, called potassium and sodium by the discoverer of them, one Davy in London, *a verra troublesome person in chemistry.*"

Davy's lectures were often attended by 1,000 persons; his youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations, and well-conducted experiments, and the auspicious state of science, ensured Davy instant success. The enthusiastic admiration with which he was hailed can hardly be imagined now. Not only men of the highest rank, men of science, men of letters, and men of trade, but women of fashion and blue stockings, old and young, pressed into the theatre of the Royal Institution to shower on him their applause.

From the year 1808 to 1814, important papers were read by Davy to the Royal Society, which are thus referred to by his brother and biographer, giving a sketch of the most important facts and discoveries which they contain, referring the chemical reader to the original for satisfaction. "After the extraction of the metallic bases from the fixed alkalies," says Dr. Davy, "analogies of the strongest kind indicated that the alkaline earths are similarly constituted; and he succeeded in proving this in a satisfactory manner. But owing to various circumstances of peculiar properties, he was not able, on his first attempt, to obtain the metals of those earths in a tolerably pure and insulated state for the purpose of examination. On his return to the laboratory after his illness, this was one of his first undertakings. He accomplished it to a certain extent by uniting a process of MM. Berzelius and Pontin, who were then engaged in the same inquiry, with one of his own. By negatively electrifying the earths, slightly moistened, and mixed with red oxide of mercury, in contact with a globule of mercury, he obtained amalgams of their metallic bases; and by distillation with peculiar precautions, he expelled the greater part of the mercury. Even now, in consequence of the very minute quantities of the bases which he procured, he was only able to ascertain a few of their properties in a hasty manner. They were of a silvery lustre, solid at ordinary temperatures, fixed at a red heat, and heavier than water. At a high temperature they abstracted oxygen from the glass, and at ordinary temperatures from the atmosphere and water, the latter of which they, in consequence, decomposed. The names he proposed for them, and by which they have since been called, were barium, strontium, calcium, and magnium, which he afterwards altered to magnesium.

"The same analogies were nearly as strongly applied to the proper earths; and he attempted their decomposition, but not with the same success.

"The application of these facts to geology was full of promise; and he indulged in the hope that they might serve to explain not only some of the most mysterious phenomena of nature, as earthquakes and volcanoes, and the combustion of meteoric stones and falling stars, but might ultimately lead to a general hypothesis of the formation of the crust of the earth." His ideas on this last subject Davy afterwards, in some measure, relinquished.

After effecting the decomposition of the fixed alkalies, Davy, reasoning from analogy, conjectured that ammonia might also contain oxygen; but his first experiments contained a fallacy. In his various papers on oxymuriatic acid and its compounds, he established the views of Scheele respecting its nature, and showed that the reasoning of Berthollet, which had generally been admitted by chemists, proved fallacious. He shows that oxymuriatic acid is not a compound, as supposed, of muriatic acid and oxygen, but an undecomposed body, to which, on account of its green colour, he gave the name of chlorine. In 1810 he published his "Elements of Chemical Philosophy," of which only the first volume was printed. His "Elements of Agricultural Chemistry," which appeared soon after, contains much useful matter, and is replete with sound and practical views on the subject.

Davy's best known achievement was his invention of the miner's safety lamp. The properties of fire-damp in coal mines had already been ascertained by Dr. Henry. When this gas is mingled in certain proportions with atmospheric air, it forms a mixture which kindles upon the contact of a lighted candle, and explodes with the violence of a tremendous piece of artillery. Such a detonation occurred within a coal mine in the north of England, so dreadful that it destroyed more than 100 miners. Davy was implored to provide a method of preventing such awful visitations; and he did it. Having conceived that flame and explosion may be regulated and arrested, he ascertained that explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at the same time, and likewise diminishing their length and increasing their number, so that a great number of small apertures would not pass explosion when their depth was equal to their diameter. This fact led to trials upon sieves of wire-gauze. It was found that if a piece of wire-gauze was held over the flame of a lamp, or coal-gas, it prevented the flame from passing; and he ascertained that a flame confined in a cylinder of very fine wire-gauze did not explode even in a mixture of oxygen and hydrogen, but that the gases burnt in it with great vivacity.

These experiments served as the basis of the safety lamp. The apertures in the gauze, Davy tells us in his work on the subject, should not be more than $\frac{1}{22}$nd of an inch square. The lamp is screwed on to the bottom of the wire-gauze cylinder, and fitted by a tight ring. When it is lighted, and gradually introduced into an atmosphere mixed with fire-damp, the size and length of the flame are first increased. When the inflammable gas forms as much as $\frac{1}{12}$th of the volume of air, the cylinder becomes filled with a feeble blue flame, within which the flame of the wick burns brightly; its light continues till the fire-damp increases to $\frac{1}{6}$ or $\frac{1}{5}$, when it is lost in the flame of the fire-damp, which now fills the cylinder with a pretty strong light; but when the foul air constitutes $\frac{1}{3}$ of the atmosphere, it is no longer fit for respiration, and this ought to be a signal to the miner to leave that part of the workings. Davy first communicated the discovery of the safety lamp to the Royal Society in 1815; on January 11, 1816, he announced the principle of the lamp, a model of which, made by his own hands, he presented to the Royal Society, and it is preserved in their collection at Burlington House. The merit of the discovery was claimed by George Stephenson; but the question was set at rest in 1817, by an examination, attested by Sir Joseph Banks, P.R.S., Mr. Brande, Mr. Hatchett, and Dr. Wollaston, who awarded the independent merit to Davy, not only in point of date, but as regards the long chain of inductive reasoning concerning the nature of the flame by which the result was arrived at. "I value it," remarked Davy, with the kindliest exultation, "more than anything I ever did; it was the result of a great deal of investigation and labour; but if my directions be attended to, it will save the lives of thousands of poor men."

The principle of the invention was this. In the safety lamp, the mixture of the fire-damp and atmospheric air within the cage of wire-gauze explodes upon coming in contact with the flame; but the combination cannot pass through the wire-gauze, and being there imprisoned, cannot impart to the explosive atmosphere of the mine any of its force. The effect has been attributed to the cooling influence of the metal; but since the wires may be brought to a degree of heat but little below redness without igniting the fire-damp, this does not appear to be the cause. The invention has been characterised as *the shutting up in a net of the most slender texture* of a most violent and irresistible force, and a power that in its tremendous effects seems to emulate the lightning and the earthquake.

Sir Humphry devoted much time to examining the state of the Herculaneum manuscripts, and illustrating chemical arts of the ancients. He analysed the colours used in painting by the ancient Greek and Roman artists. His experiments were chiefly made on the paintings in the baths of Titus, the ruins called the Baths of Livia, in the remains of other palaces and baths of ancient Rome, and in the ruins of Pompeii. By the kindness of his friend Canova, who was charged with the works of ancient art in Rome, he was able to select with his own hands specimens of the different pigments that had been found on vases discovered in the excavations which had been lately made beneath the ruins of the palace of Titus, and to compare them with the colours on the walls, or on fragments of stucco. The results of all these researches were published in the *Transactions of the Royal Society* for 1815, and are extremely inte-

perfectly defined image but two-thirds of its focal length. Such a result is not to be attained by the employment of two lenses only, no matter how achromatised. This objective is admirably adapted for showing large pictures in small rooms, as an increase of angle of field is equivalent to a lens of shorter focal length with a proportionally larger aperture; but, unfortunately, the two cemented surfaces present a great drawback to its employment in combination with weak lights, such as the Argand burner, though this does not obtain when we are using the lime-light apparatus.

(5.) The "periscopic lens," wherein the radius of the concave face is less than that of the convex face, and consequently the concavity is greater than the convexity, as shown at E, which is constructed of a plano-concave flint cemented to a plano-convex crown lens. In this form the marginal rays are refracted to a greater extent than the axial to secure flatness of field. One of the first achromatic lenses of this character was made for the Rev. J. B. Reade by Andrew Ross, and in more recent years this form was sold by the late J. T. Goddard of Hounslow, an honoured name on the roll of inventive opticians.

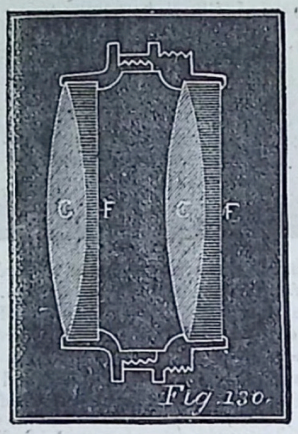


Fig 130.

(6.) The "double periscopic" lens of Goddard, shown at F, of peculiar construction, so arranged, that when placed in a suitable position, oblique rays would be corrected. It consists of a double-convex crown cemented to a double-concave flint, the two neutralising each other in respect of magnifying power, the back element being a meniscus of deep curvature, neatly cemented by flatly-ground edges to the front combination, so as to enclose an air-cavity, A. The single achromatic usually supplied for lantern purposes are those figured at A and B (Fig. 129); but the other forms, employed in photography, are eminently suggestive for improvements in lantern construction, if we bear in mind that the coincidence of the chemical and visual foci, the *sine quâ non* of the photographer, which adds greatly to the cost of production, is not essential for ordinary lantern purposes.

The double achromatic lantern power consists of two achromatic plano-convex or two achromatic meniscus lenses arranged close together, as shown in Fig. 130. To work with condensers of 3½ inches diameter, each combination is of 8 inches focus, forming a double combination of 4 inches focus. To work with 4-inch condensers, each element is of 9 inches focus, producing a combined focus of 4½ inches. This is a very serviceable arrangement, for by unscrewing the back lens, and inserting "the lengthener," L (Fig. 121), it is immediately converted from a short to a long focussed combination: in the first case giving a flat field, imperceptibly free from distortion, unless sought for with hypercritical eyes; in the second case the same applies, as with the long focus there is less strain on the lens. This arrangement used as a double combination presents advantages over the next power described when used in a small room, for while with this lens we may reckon that for every foot on the screen we must pull back the lantern one foot, with a photographic portrait lens we must pull back eighteen inches and in some cases two feet; so that while with one power we should have to place the lantern 10 feet from the screen to get a 10-foot disc, with the other we should have to place it at 15 feet, and with the third 20 feet away to get a 10-foot picture, while, as a rule, we could only get a range of 20 feet in a public institution, not a private residence.

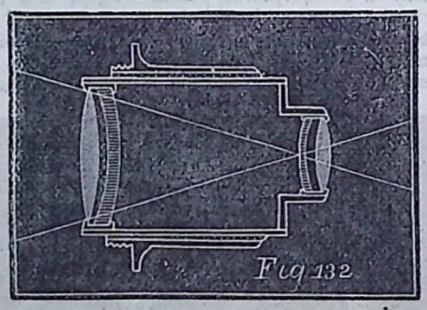


Fig 132

Having described the single and double achromatic lantern power, it is necessary to state how it is mounted to admit of its being attached to the lantern by means of *the jacket*, shown at J (Fig. 121). The jacket consists of a stout brass tube that screws directly into the front tube, T′ (Fig. 121), if a double combination power is employed; or into the lengthener, L, if a single long-focussed power is required. Within the jacket, J, is a longer tube that can be worked to and fro, either by a sliding motion like a telescope tube (in which case the jacket should be lined with cloth, not only for the purpose of making the action freer, but for keeping the inner tube polished), or by means of a rack-and-pinion motion, M, fixed to jacket and inner tube. Into the end of the inner tube next to the lantern the power screws, the front end being finished by an ornamental casting. Within the inner tube, another is fitted that carries the diaphragm or stop, S. The diaphragm is, as a rule, a powerful agent in the hands of the optician: by decreasing its aperture, greater sharpness of the image is secured; by placing it in the best position near to the lens, spherical aberration may be reduced and distortion corrected, according to the nature of the shortcoming he most wishes to surmount; for, as I have already said, optics is a game of give and take, and the optician has constantly to "rob Peter to pay Paul;" but when using a stop for the magic lantern, it can hardly be said that it is employed as an optical element; for as we cannot afford to lose light by cutting off any of the marginal rays of the transmitted beam, it is really only used to shield the screen from that glare which is reflected from the marginal surface of the power, in a manner that detracts so much from the brilliancy of the enlarged picture, if the stop be removed.

The photographic portrait lens, of the size known as the quarter plate, with a focus of 4½ inches, makes one of the best achromatic powers for the lantern if the operator is not confined for space. The short-focussed stereoscopic lens of the same construction is unsuited for this purpose, as it will not cover a 3-inch slide; while the *carte de visite* lens, likewise of the same type, is too long in focus for ordinary use, though it would be the very best arrangement, as the corrections are made with a view of including objects standing nearly in one plane. For exhibitions in theatres or halls of great length, the half-plate portrait lens, from its extra length of focus and greater diameter, serves the purpose to perfection, for though it may be said that a lens producing pictures on a flat screen *absolutely* free from distortion and curvature of field is next to an impossibility, the nearest approach to perfection is attained when the diameter of the lens equals that of the picture to be reproduced, and its focal length is long in proportion to its size, while the objects to be reproduced are situated in one plane, at right angles to the general axis of the lens. The most convenient half-plate lens for magic-lantern purposes at theatres, halls, etc., is that arranged by Derogy, as it is provided with extra lenses, by which the normal focus may be lengthened or shortened, so that it meets any requirements at a public exhibition as to distance between lantern and screen. In such cases the extra cost must not be permitted to be a matter of consideration.

The double portrait lens invented by Petzval may be said to be the direct antithesis to the wide-angle single combination, for while the latter embraces a large area when worked with a small stop, the former includes only a small angle of view with a large stop.

It consists of an achromatic meniscus (nearly plano-convex) crown and flint cemented front combination, F C (Fig. 131), the convex surface of which is turned towards the object to be reproduced when used for photographic purposes, and towards the screen when fixed in the lantern; this is set in a cell which screws into a tube that works to and fro in the jacket, J, by a rack-and-pinion motion, M. The back is a double-convex combination formed of a divergent meniscus of flint glass, F, kept at a certain distance from a double convex of crown glass, C, by a ring, the three fitting into a cell that screws into the other end of the brass tube. The position of the diaphragm is shown at S, which is used at full aperture when employed for lantern purposes. A cap, O, fits on to a metal shade that screws over the front combination, which is useful for covering and uncovering the lens when a slide is changed. Dr. Monckhoven has modified the ordinary form of Petzval's portrait lens for the special requirements of "photographic enlarging," in a manner that also meets the wants of the lantern exhibitor. He makes the

back combination just large enough to include neither more nor less than the entire cone of rays from the condenser when they are brought to a focus on the front combination, so that there shall be neither loss of light nor diffraction blurs (which would arise if the rays impinged on the metal mount), and the front only about half the diameter of the back combination, with its elements separated, as shown in Fig. 132, and not cemented in the usual manner. For photographic portraiture it is necessary that the front combination should be as large or nearly so as the back, but this does not apply to an objective that is required for the production of enlarged images only, and the reduction of the diameter of the front lens prevents "fogging," or that reduction of the brilliancy of the image, through diffused light, to which I have previously referred. On the other hand, equality in the diameter of the portrait lens presents this advantage, that if the screw-fittings of the back and front combinations be of the same gauge, if a long-focussed lens is required, we have only to remove the back combination and screw the front one in its place (consequently in a reversed position), which Monckhoven's arrangement does not admit of. Again, it must be noted, that while of late years quarter-plate portrait lenses have been made so that the long-focussed front combination can be used for landscape work in the manner above described, nevertheless such combinations are not the best form of single achromatics that can be employed, as something must be sacrificed to make them work to the best advantage in conjunction with the back combination as a portrait lens.

The smaller the picture required the nearer must the lantern be placed to the screen, and the further must the power be racked away from the slide, and *vice versâ*. In focussing for the sharpest definition, if the screen is some distance off, it is well to observe the image with an opera-glass, as the eyes of the operator are liable to get dazzled with the bright light; but observe, if coloured slides are being shown, it is better not to seek *too* sharp a focus, for then every stroke of the brush is shown as in a microscope, while a more pleasing effect is produced if the image is softened by being just out of the sharpest focus.

COTTON-SPINNING.—III.

By J. Robertson.

COMBING MACHINE—DRAWING-FRAME.

The importance of cotton-spinning as a branch of the great manufacture which has become the staple of this country, and which affords the chief source of support to the thousands of busy operatives who are to be found in the manufacturing towns and districts of Lancashire and Yorkshire, can scarcely be overrated, as on its management depends the preparation of the yarns from which are woven the various kinds of cotton cloth ranging from the fine and semi-transparent muslin to the coarse and substantial fustian. There is not one of us throughout the length and breadth of the United Kingdom, from the highest to the lowest in the land, who does not at some time of the year wear some article manufactured from the fibres of the useful cotton plant, while much of many miles of cotton cloth of one kind or another which are turned out yearly by British weavers from British looms are sent across the seas into all parts of our colonial possessions, and even to the very countries which were the cradle of the weaver's art. We can scarcely, then, dwell too much at length on the machinery employed in cotton-spinning, or fear to be too diffuse in giving an explanation of the working of each machine and the results of its action on the cotton fibre, when we reflect on the importance of this art as a branch of British industry.

Of late years a combing machine has been largely introduced instead of the second carding-engine. Although combing does not form a necessary step in the preparation of the cotton, it yet requires a special notice. For fine counts and for sewing thread it far surpasses the carding-engine, being much more efficient in removing the short fibres which tend to weaken the yarn. It can only operate upon carded cotton, as it is essential that the fibres be presented to the combs longitudinally.

The principle of this machine may be better understood by a reference to the accompanying sketch (Fig. 1). The lap, A, is unwound without any strain being put upon it—just as at the finishing carding-engine—passes between the feeding rollers B and B′, and also between the "cushion-plate," D, which is covered with leather, and the nipper, C. The feed-rollers have an intermittent motion, and allow a little less of the fleece to pass at a time than is equal to the length of fibre which is to be combed and retained. No sooner do the rollers stop than the nipper comes down upon the cushion-plate, which is held in its place by a spring, and pushes it back, until the fibres which have been caught between them are in the best position for being acted upon by the roller E, on one part of whose circumference there are about a score of combs. Each of these in succession is finer than its predecessor, there being about thirty teeth to the lineal inch in the first and about 100 in the last. When these combs have passed through the portion of lap held to them, the nipper and cushion-plate move forward to their former position, where the cotton is caught between the roller G and the corrugated segment of the roller E. Simultaneously, the fine comb F drops into the tuft, and the nipper rises. As the cotton which has been combed passes forward, the tail-ends of the fibres are straightened by the comb F, which at the same time prevents those whose front ends have not been combed from going forward. To make a continuous sliver the rollers G and G′ turn backward slightly before drawing forward the cotton, so that each successive tuft is "pieced" to the one preceding. Several slivers are then combined and coiled in a can. The short staple cotton which has been taken out by the combs is stripped off them by the revolving brush H, which throws it upon a card-clothed doffer, J. This doffer has the fibres taken from it by a reciprocating comb, K, as in the carding-engine. The sliver thus produced is available for coarse yarns.

The part which the drawing-frame acts in the preparatory operations of the spinning factory is one of great importance. The cotton fibre is naturally undulating and sinuous, and this characteristic is to be found in the fibres composing the sliver produced by the carding-engine, preventing them from lying so parallel and close upon each other as it is desirable that they should before being twisted or spun. The principle upon which the drawing-frame operates to remedy this, and to equalise the grist of the slivers, is that of doubling and drawing, or elongating by means of rollers revolving at different velocities. This machine is exceedingly simple in its construction. Upon a suitable stand or support is placed a series of rollers, about $1\frac{1}{4}$ inches in diameter, in pairs, as seen in Figs. 2 and 3. The lower ones are fluted, whilst the top ones are, with the exception of the first which is also fluted, clothed with flannel and leather nicely pieced together at the edges so as to form a perfectly smooth and unbroken surface, and at the same time to be somewhat elastic. These rollers perform the same functions which the finger and thumb were wont to perform before the introduction of machinery. Six or eight slivers from the carding-engine are passed between several pairs of rollers. Now let us suppose for a moment that all these rollers revolve at the same speed, it is obvious that little or no change will be effected upon the slivers in their progress. But if the second set of rollers B revolve a half faster than the first A—that is, make $1\frac{1}{2}$ revolutions for one of A—it is equally obvious that the sliver will be drawn out, the fibres gliding upon one another, until it is a half longer. And so likewise in the case of the third and fourth rollers, C and D. But in their case the "draught," as it is technically called, is so very much increased that the combined slivers are delivered as one of about the same size as one of those of which it is composed. No precise amount of doubling and drawing can be fixed upon as neither less nor more than sufficient. It may be supposed that the oftener the cotton is drawn and re-drawn, the more thoroughly would the slivers be equalised in size, and the component fibres straightened and consolidated. In practice it is considered that a sufficient approximation to perfection is made by the use of a drawing-frame of three "heads" of four "deliveries" each. These "heads" are, indeed, complete machines in themselves, for whilst the framing and main driving shaft are common to all three, the rollers of each are driven independently. Against each "delivery" there are stops and other necessaries for eight supply-cans, so that any number of slivers up to eight can be combined as is thought best for the particular class of cotton which is in process. Short staple cotton usually requires less drawing than long staple, long fibres

being much more liable to double up in the carding than the others. Suppose, then, that eight slivers are combined and drawn into one at the first head; eight slivers from the first head are combined and re-drawn at the second; and again from the second eight slivers are drawn at the third, the result is that the finished sliver has undergone 512 doublings and drawings. It is found that the drawing is better performed when the first and second pairs of rollers run about the same speed, in fact act simply as conductors, whilst one-half of the drawing is accomplished between the third and fourth. As it is of immense importance to have the rollers adjusted to suit the staple of the cotton, they are constructed with movable bearings, so that they can be shifted to a greater or less distance apart. Should the distance between the points of contact in the different sets of rollers be less than the length of the staple, the result will be that the fibres, held by the one and drawn by the other, will be torn, to the great weakening of the yarn when finished. On the other hand, care must be taken to see that the rollers are not so widely apart that the attenuated sliver is in danger of falling asunder from its own weight. To prevent unevenness and clouding in the drawn web it is necessary to have the circumferences of the upper and lower rollers pressed firmly together, so that there may be no slip of the cotton; and for the same reason it is desirable to have as light a sliver as possible. When it is too bulky the edges are apt to be drawn away more freely than the centre part, which bears the principal weight. There is another difficulty which is felt to be somewhat serious. The rollers are generally made with two separate bosses, which it is not always possible to clothe with exactly the same thickness of flannel and leather, and the consequence is that the smaller one is driven more rapidly than the other would be if working by itself, which causes abrasion of the surfaces. To remedy this an improved roller has been invented, in which the bosses are made separately and run loose upon the roller. This system of loose bosses is now very generally adopted for the front roller where the work performed is greatest.

On the top of the rollers a piece of wood covered with flannel rests, which serves as cleaner to sweep off any fibres which may have adhered to them and to keep their surfaces smooth and polished. To prevent the inequality which would arise from the rollers continuing to revolve after one or more of the slivers have run out or broken, stops are introduced, which are acted upon individually by the slivers before they reach the first drawing-roller. A lever, furnished on the top end with a hollow or recess in which the sliver runs, is balanced so that, on the weight of the sliver being withdrawn, it rises, and, by a very simple connection with the belt-guide, throws the belt upon a loose pulley, and instantly stops the rollers. In the event of the slivers at the delivering side of the machine lapping round the rollers or breaking, a similarly balanced lever also brings the machine to a stand. The leather upon the rollers of the drawing-frame is very liable to be affected by damp, and it is of importance to have the atmosphere of the apartment in which they are placed thoroughly dry. The adhesiveness caused by dampness inclines the cotton to lap round the rollers, and sometimes great annoyance and trouble is caused by this, not only in the drawing-frame rollers, but in the rollers of all the subsequent machines.

The equalising of the slivers and the straightening and laying parallel of the fibres has now been sufficiently accomplished to render it fit to be carried forward another stage in the process of preparation. What now remains to be done before the cotton reaches the mule or throstle-frame is simply to reduce the sliver as nearly as possible to the size of the yarn which is to be spun. It is impossible to accomplish this by one operation. The sliver made by the drawing-frame is as fine as it is capable of being made, consistent with the strain to which it is subjected in being withdrawn from the can, with a view to further development. At each of the next stages, therefore, its further attenuation renders it necessary to have it strengthened by imparting a slight twist. This is done in the fly-frames. A machine has recently been invented to supersede the slubbing or first fly-frame, called the duplex slubbing-frame. It is somewhat similar in its action to the drawing-frame until the sliver, which has been greatly attenuated, issues from the last roller. Here, instead of being conveyed by calendar rollers directly to the coiler, it is first passed through a tube, and brought out by an eye upon one side of it. This tube revolves at a considerable velocity, and imparts a corresponding amount of twist to it, until it escapes from the tube, when the twist is again undone. This machine serves its purpose very well, the sliver being found sufficiently strengthened by the consolidation which the temporary twist has given to the fibres. Its chief recommendation is its cheapness and simplicity. The sliver from this machine is taken to the second or intermediate fly-frame. Other machines have been patented likewise for doing away with one of the more costly fly-frames, but none of them have up to the present time proved successful. This frame has not been sufficiently long in use to enable a proper estimate of its merits to be made.

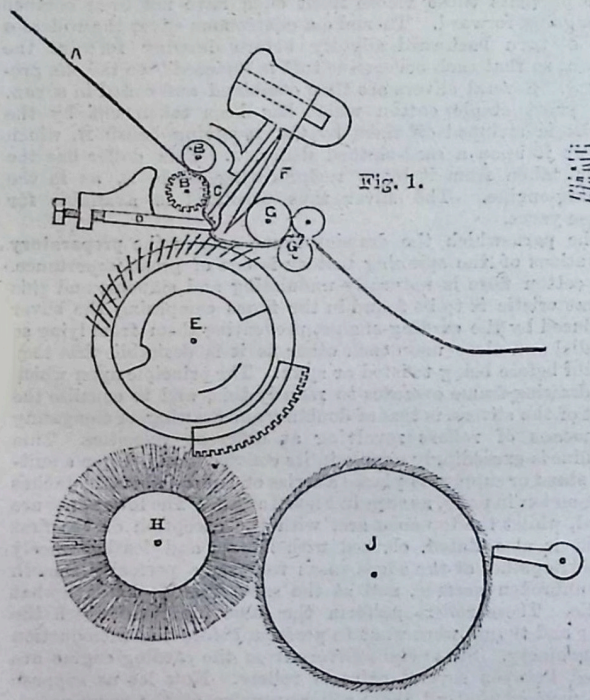


Fig. 1.

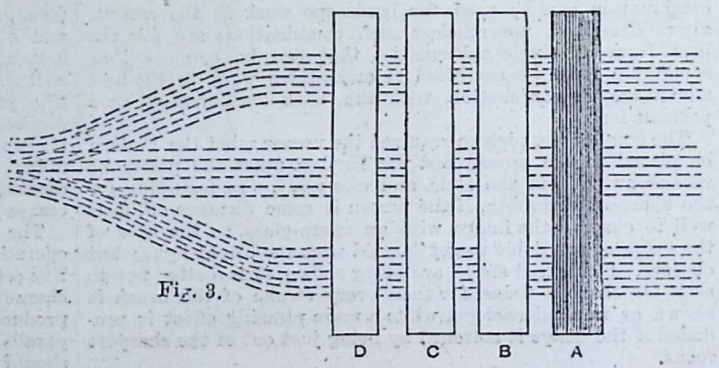


Fig. 3.

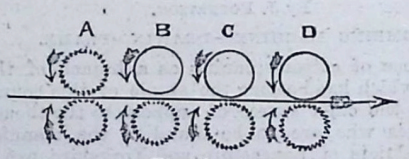


Fig. 2.

MINING AND QUARRYING.—XXXVII.

BY GEORGE GLADSTONE, F.C.S.

SALT (*continued*).

MINING AT NORTHWICH—WIELICZKA—BEX—BRINE WELLS—MANUFACTURE FROM BRINE IN ENGLAND—FROM SEA-WATER BY EVAPORATION—BY FREEZING.

THE mining of rock salt must now be considered, though the product is not used to any very great extent in this country in the condition in which it is raised from below. A good deal, however, of the purest rock is exported as such; the rest is usually too much impregnated or intermixed with clay, gypsum, and oxide of iron, to be employed without first undergoing a process for the separation of these impurities.

If the bed of salt is large and solid, as at Northwich, the mine is often not only free from water, but very dry. In such case the shaft is sunk as in ordinary mines, cased with timber, and divided into the necessary compartments for hauling up the produce, for fixing the ladders required in descending and ascending, etc. The hauling is usually done by steam-power. The underground workings consist of galleries driven through the rock, opening out into wider spaces where the nature of the deposit encourages more extensive workings, and especially where a good and firm roof can be obtained. Where the roof is tender large pillars of rock salt are left to support it, or it is propped up with timber.

At Wieliczka the thick beds of rock salt are perfectly dry, and the only moisture that is observable in the upper part of the mine occurs in the earthy partings. These strata being rather soft, the drifts through them are frequently timbered and boarded, and a wooden gutter is made to carry off any little water that may issue; but in driving through the salt the rock itself forms the side walls and roof, and presents very much the appearance of a light-grey granite, the large unbroken crystals of transparent rock salt resembling, in the dim light of the mine, those of felspar in the granite. In some of the large excavations referred to in the previous article the amount of staging built up of timber is very considerable: this not only serves to prevent accidents from the giving way of the roof, but facilitates access to different levels. The salt is worked out by gangs of miners, who, with a sharp-pointed pick, undercut the rock at the level of the floor, and divide the face of the working also into compartments by perpendicular grooves about ten feet apart; the masses thus isolated are then removed by blasting, and the fragments brought down by the explosion are trimmed into rectangular blocks, and removed in trucks, which run upon trams to the shaft bottom, to be brought to surface. The salt is sold in blocks just in the condition in which they are raised, and it is so pure as to be fit even for domestic use. The water, which in one part of the workings is abundant, is collected into a couple of lakes united by a canal at the bottom of the mine, the whole of which is excavated in the salt itself, the latter not being affected by the water, as it consists of a saturated brine.

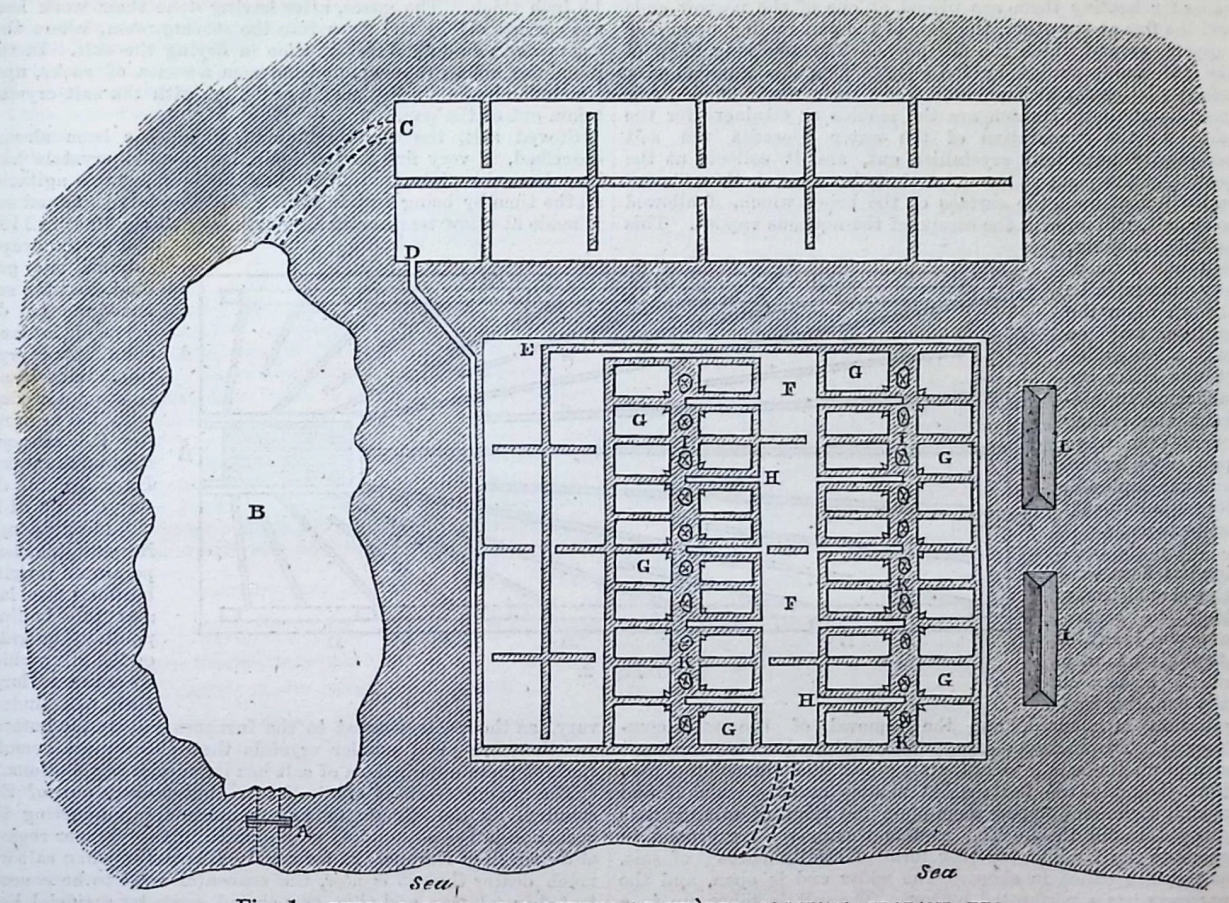


Fig. 1.—TYPICAL PLAN OF SALTERNS AT HYÈRES, CAGLIARI, TRAPANI, ETC.

The mines of Bex in Switzerland present a complete contrast to this one. The workings there consist of a long horizontal drift into the side of the mountain, opening out into spacious excavations and shafts to other levels; but throughout the whole mine water is continually dripping from above, so that it has to be collected into great reservoirs, and the salt is obtained in a state of solution just as in the case of a brine spring. The salt mines in the Eastern Alps (Tyrol and Salzkammergut) partake of much the same character.

The brine-springs themselves most commonly proceed from the saliferous marls which immediately overlie the solid salt; and in utilising them it is desirable to secure as strong a brine as possible. It is usual, therefore, to make a double casing to the well, and to ram clay into the space between the two, so as

to exclude all surface water; and when this has thoroughly consolidated, to push the boring down till the brine is met. In England steam-pumps are generally used now to raise the salt water, and pump it into the great reservoirs prepared for its reception; but on the Continent water-power is employed in the great majority of cases.

In this country the following plan is usually adopted for the purpose of separating the pure salt. The solid mineral, being generally impregnated with iron and other impurities, is thrown into the reservoirs just referred to, so that the brine is kept up to the saturation-point. The liquor is drawn off as required into the evaporating pans, which are shallow vessels of wrought iron having an area of 1,000 to 1,800 feet, and a depth rarely exceeding eighteen inches. They are oblong in shape, the length usually about three times the breadth, and the furnaces for heating them are placed at one of the narrow ends and the flue at the other, the floor of the pan resting upon iron supports around which the fire plays. The two long sides of the pan are occupied by the workpeople, who stand upon a raised platform which extends along their whole length, and immediately behind which are the moulds or strainers for the salt. As the evaporation of the water proceeds the salt necessarily begins to crystallise out, and it collects at the bottom of the pan; at the same time, however, a thin film of salt will float upon the surface of the brine, which, if allowed to remain, will impede the escape of the aqueous vapour. This pellicle, however, will not form if any oil or resin be thrown upon the surface, and as only a few grains of the latter are sufficient to prevent the setting over, even when pans of the largest size are employed, its use is decidedly advantageous.

When the boiling has been continued sufficiently long to ensure a considerable deposit of salt at the bottom of the pan, the temperature is reduced, and the removal of the salt commences. The workpeople, supplied with long-handled "rakes," scrape up the salt into heaps all along each side of the pan, then they take up the wooden moulds or tubs which stand behind them, and placing them upon the ridge of salt crystals proceed to fill them. The moulds themselves correspond in shape to the familiar tapering form of the "squares" of salt, as they are called in shops. The wider end is open, and the narrower has a perforated bottom. The salt is taken up in a perforated shovel, called a "skimmer," and poured into the mould; when full to the brim the salt is worked about with a short thick stick, the "rammer," until it has subsided to about half the height of the mould, the greater part of the liquor having been forced out through the perforations and crevices. The mould is then re-filled, and the salt piled up above the level of the top; this is beaten down flat with a wooden mallet, and the mould is then set aside to drain. The squares of salt are afterwards removed to a heated chamber to be finally dried after having been taken out of the moulds.

When all the salt deposited at this boiling has been removed, fresh brine is let into the pan to fill it again, the fires are got up afresh, and the same process is repeated. Three batches of salt may thus be withdrawn from each pan in the course of the day. As the operation is a continuous one, and the liquor remaining is not withdrawn, but is left to mix with the fresh brine, the carbonate and sulphate of lime, a small quantity of which is generally to be found associated with the chloride of sodium, gradually accumulates on the bottom of the pan, and if allowed to remain would exercise the same injurious effect that the fur does on the inside of boilers. This "pan scratch" has therefore to be removed periodically by means of sharp picks; and it is used for mixing with refuse salt, to be sold to agriculturists.

At the salt works of Dürrenberg, in Prussian Saxony, a very good arrangement is in use for the economical evaporation of the brine; and every plan which tends to effect a saving in that most precious article, fuel, is well deserving of attention. The pans used have an area of about 1,060 square feet, and each is heated by a single furnace, the grate of which measures eighteen square feet, and the supports for the pan radiate from the furnace, as shown in Fig. 2. A represents the size of the pan, B the fire-grate, and C, C the supports, which are so arranged as to distribute the heat effectively before passing into the flues D, D. The supports are broad below, but taper as they rise, so that the part of them on which the floor of the pan rests is only 1½ inch thick. The gases, after having done their work here, are carried off by the flues into the stoving-room, where they are made to do duty a second time in drying the salt. In this room the flues are conducted between a series of racks, upon which the baskets are placed when filled with the salt crystals taken out of the pan.

Stoved salt, the manufacture of which has been already described, is very fine in the grain, because the crystals have been formed rapidly, and the liquor has been kept in agitation all the time by being on the boil. Coarse or large grained salt is made at a low temperature, sometimes at only 100° to 110°, so that the evaporation is very gradual, and the salt has time to develop into large solid cubic crystals. In such case five or six days will be required for the evaporation of the water. Intermediate descriptions will be obtained by adopting suitable temperatures ranging between this last and the boiling-point. The grain of the salt yielded by a pan of large size will indeed vary, as the parts nearest to the furnaces will be the hottest, and therefore yield smaller crystals than those more remote. Each of these descriptions of salt has its special applications.

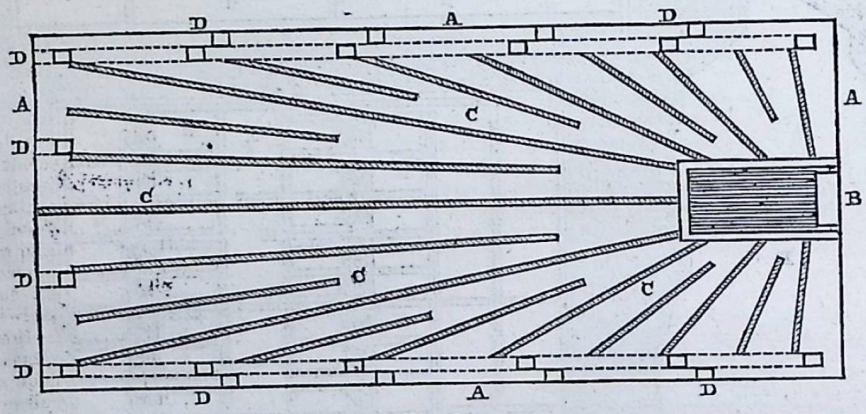


Fig. 2.

The manufacture of sea salt has almost died out of this country, as the climate is unfavourable for conducting the operation in the economical way adopted in the warmer regions of the south of Europe. In former days, however, when salt was much dearer than it is now, the sea-water used to be concentrated in salterns, and then evaporated down by artificial heat until the whole of the salt was deposited. The salterns now in use at Hyères, Cagliari, Trapani, and other places on the shores of the Mediterranean, are laid out on a very extensive scale. The plan (Fig. 1) in the preceding page will show the principle upon which the operation is carried on. They extend along the flat shores, protected by a sufficient embankment from the rise of the tide. A flood-gate at A admits the sea at high water into the collecting pond B, in which any sand or other matter mechanically suspended in the water is deposited, before the latter is admitted into the salt gardens. These are so arranged and subdivided by embankments that the water has to perform a long course before it reaches the crystallising ponds. The sun and the hot air of the summer months causes so great an evaporation that sometimes the salt will be deposited after a single day's exposure, though two or three days are more generally required. From the collecting pond the water passes into the first pool at C, and has to traverse this one to the extreme end and back again, before reaching the exit at D. This pool is made very shallow, so that a large surface of water is exposed to the heat of the atmosphere, and the evaporation is proportionally great. From D the channel passes round the saltern,

and the water enters the second series of ponds at E, and after making the circuit of these, passes into those marked F. By this time the water is just about fully saturated with salt, and as soon as it is found to be ready to crystallise out, the brine is drawn off into the crystallising ponds G, G. Each of the small channels H, H will be observed to supply four of these ponds, through a pipe entering at the nearest corner, which is opened and closed, as required, by a wooden plug. The salt is raked out and piled in heaps, I I, on the platforms K K, which run between the two series of crystallising ponds; the mother liquor drains out and flows back into the latter, and when the salt no longer continues to form, the spent liquid is drawn off and allowed to run into the sea. The salt, after it has drained dry, is removed from K and made into large heaps as at L, which are covered with straw to keep off the rain: it remains here until the chloride of magnesium, which is always present in freshly-made sea salt, and which is very deliquescent, has absorbed sufficient moisture from the atmosphere to become melted, and has drained away. The remaining salt will then be sufficiently pure for use.

There is another mode of separating salt from sea-water which is sometimes practised, and which depends upon a totally different principle. Cold, instead of heat, is used in this case for the purpose of making a concentrated brine; and it is practically applied with advantage on the shores of Eastern Siberia and other northern regions where an intense degree of cold prevails in winter. It is a matter of familiar experience that salt water does not freeze so readily as fresh, and it is found that in freezing a change takes place in the arrangement of the particles whereby the saline ingredients are to a great extent separated from the rest, and remain in a liquid state while the water thus deprived of the greater part of the salts is converted into ice. By this means a tolerably concentrated brine can be obtained, from which the salt can be crystallised out with a slight expenditure of fuel. Sea-water, however, contains salts of calcium and magnesium as well as sodium, and under the influence of cold the sulphate of magnesia and chloride of sodium will mutually decompose each other, forming sulphate of soda, otherwise known as Glauber's salts, and chloride of magnesium. These, as well as other substances formed in the salt thus prepared, render its use undesirable as an article of food.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Galletly, Curator, Industrial Museum, Edinburgh.

V.—MANUFACTURE OF WOOLLEN CLOTH.

If we compare together a piece of superfine broad cloth and a piece of any worsted fabric, say "merino," we shall find that in the former there is no appearance of its being woven, because after the process of felting, which all such cloth undergoes, the warp and weft threads are hidden from view; while in the worsted fabrics these threads are very distinctly seen. Since both "woollen" and "worsted" goods are composed of the same animal fibre, it seems strange to say that they are prepared by unlike processes; by machines which are not only different, but opposite in principle; and by workpeople whose experience in the production of the one class of fabric is of little or no service in the manufacture of the other. Such, however, is the case, and the reasons for these differences will appear as we proceed. The maker of fine broad cloths aims, as Mr. George Leach, of Leeds, himself a manufacturer, expresses it, at making a fabric which will "resemble as much as possible a fine short fur." To obtain this result, "woollen yarn" requires to be prepared with the fibres in great part transverse to the axis of the thread; in fact so that, if magnified enough, it may roughly resemble a bottle brush, where the projecting bristles would represent the "pile," and the twisted wire the inner portion or heart of the yarn. It is these projecting portions of the wool which interlock and mat together in the milling process, and which, with many additional points, are afterwards raised by the teazles and cropped to a uniform length, so as to leave a smooth even surface on the cloth.

The worsted manufacturer, on the other hand, requires his yarn to have the fibres as much as possible parallel to each other, so that it may be even, strong, and composed of few filaments. Worsted yarn is besides always harder spun than woollen, the latter being but slightly twisted in order to leave the fibres as free as may be for the felting process. The quality of worsted goods depends in great part on the softness and rich appearance, as well as the fineness of the yarn, these properties giving its character to the finished fabric, in which the number of threads in a given space can be easily counted. With this brief description of the difference between woollens and worsteds, we proceed to explain the successive stages in the production of woollen cloth, stating at the outset that the processes are more numerous and complicated than those of any other textile manufacture, and are performed by a greater variety of machines and workpeople. It will be useful to give here a full table of these processes, as a sort of key to what follows, it being only necessary to describe in detail the more important ones.

The various stages in the manufacture of woollen cloth, then, are:—1. Wool as shorn from the sheep and sorted into different kinds. 2. Scouring in alkaline liquor. 3. Washing after scouring. 4. Drying in drying machine or heated chamber. 5. Dyeing when dyed in the wool. 6. Willowing or dusting. 7. Cleaning by burring machine. 8. Oiling and teasing. 9. Scribbling by first carding-engine. 10. Carding by intermediate carding-engine. 11. Carding by finisher carding-engine, and forming sliver by condenser. 12. Spinning into yarn, "warp or weft." 13. Warping. 14. Sizing. 15. Weaving into cloth "raw-thread." 16. Scouring. 17. Burling. 18. Milling or fulling. 19. Scouring again. 20. Drying or tentering. 21. Raising or teazling. 22. Shearing or cutting. 23. Brushing by revolving brushes. 24. Pressing. 25. Boiling and cleansing. (25*a*. Dyeing when piece-dyed.) 26. Shearing again. 27. Picking, drawing, or marking. 28. Pressing again. 29. Steaming. 30. Folding or packing.

Wool used for any special branch of manufacture is selected from certain parts of the fleece, which is accordingly divided into "sorts" or qualities by experienced sorters or staplers. The number of these sorts vary in different fleeces, but they are seldom fewer than six, and sometimes as many as twelve. In the case of a German fleece divided into six portions, the various kinds are thus described by Professor Archer, in his report on the International Exhibition of 1871:—The *first* is that which grows upon the flanks and ribs near the shoulder; the *second* is from the lower part of the haunches; the *third* is from the part extending from the shoulders down to the knees; the *fourth* is from under the neck; the *fifth* from the hinder part to the tail and beginning of the back; and the *sixth* is from the head, between the thighs, and from the breech But this disposition of the various qualities is subject to much variation, which the skilled judgment of the stapler at once detects.

After the sorting, the first process is *scouring*, by which the wool is cleansed from the grease with which it is naturally impregnated. Upon the care taken at this stage depends much of the success of succeeding operations, but especially of the dyeing, which can neither be brilliant nor permanent if the scouring is inefficiently performed. Previous to 1853 it was usually done by hand. In that year Mr. J. Petrie, jun., of Rochdale, patented a wool-scouring machine. This excellent machine consists of a long trough containing alkaline lye, in which four rakes are made to "pass or drag the wool automatically from the continual in-feed of wool until it reaches the new patent slide-lifter, which transfers it in regular quantities, according to the feed, to the squeezing rollers." These rollers express the surplus liquor, and the wool is then thoroughly washed in water as pure and soft as possible. The apparently simple operation of drying the wool requires careful attention, because if either too much or too suddenly heated, it becomes harsh and brittle. A very efficient plan is to spread the wool on galvanised wire-work, and then blow either hot or cold air through it by means of a blast-fan. This dissipates the moisture while it retains the natural softness of the fibre.

Passing for the present the dyeing, which takes place at this stage when "wool-dyeing" is resorted to, we come next to the *willowing* or *willying* process, which opens and disentangles the locks of wool, and so clears it of sand, dust, seeds, and other impurities. The willow, or as it is sometimes called, the devilling machine, is of various forms, a vertical section of one being shown in Fig. 17. It consists of an open cylinder or drum, (C), with twelve ribs, on each of which is a row of spikes. Three rollers (B), each with ten rows of similar spikes, are placed over

the drum, so that when the machine is in motion the spikes on the rollers pass through the spaces between those on the drum. By this arrangement, coupled with the rapid motion of the machine, the wool is opened, and the impurities which separate fall through the wire cloth (W).

Many wools contain peculiar seeds, called "burrs" and "prepared," that is, the matted portions are torn open to make it more easily carded. The machine is termed a "wool-oiling and preparing machine." The oiling apparatus is so constructed that the oil, by means of a series of jets or gutters, falls in a kind of cascade on the wool as it passes along the "feed" to the teasing cylinder, which revolves at a high speed, and is covered

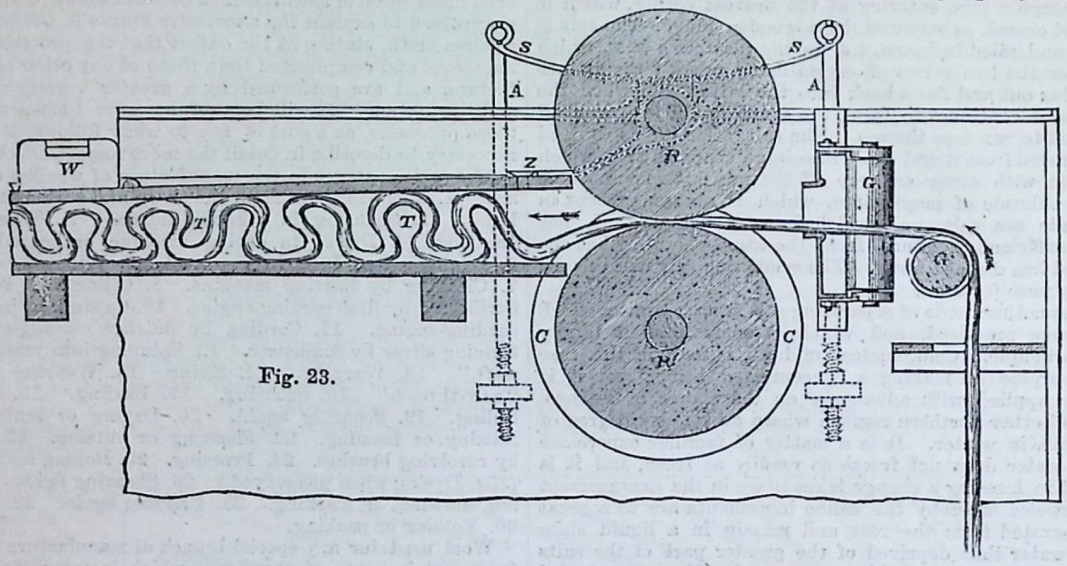


Fig. 23.

"moiets," very difficult to remove, as they are covered with prickles, which adhere firmly to the fleece. To clean the wool of these troublesome seeds, the *burring machine* was brought into requisition, and, like the willy, it is of different forms. One of the best is manufactured by Platt, Brothers, and Co., Oldham, who thus describe its action:—"The wool is fed upon a travelling cloth or table through a feed-roller and dish to the action of a beater, and delivered to a series of rollers to charge the first fine-comb cylinder; the surplus wool-burrs, etc., from the cylinder are stripped by a guard-roller, and deposited upon a

with steel teeth to separate and loosen the wool into small tufts, which are then thrown out on the floor ready for carding.

Carding is one of the most important operations in the manufacture of woollen cloth, because the quality of the yarn greatly depends on the manner in which it is executed, it not being easy to remedy the effects of defective carding in the subsequent stages. There are usually three machines employed in the process—namely, the scribbler or first carding-engine, the intermediate or second carding-engine, and the finisher carding-engine and condenser. The general construction of these

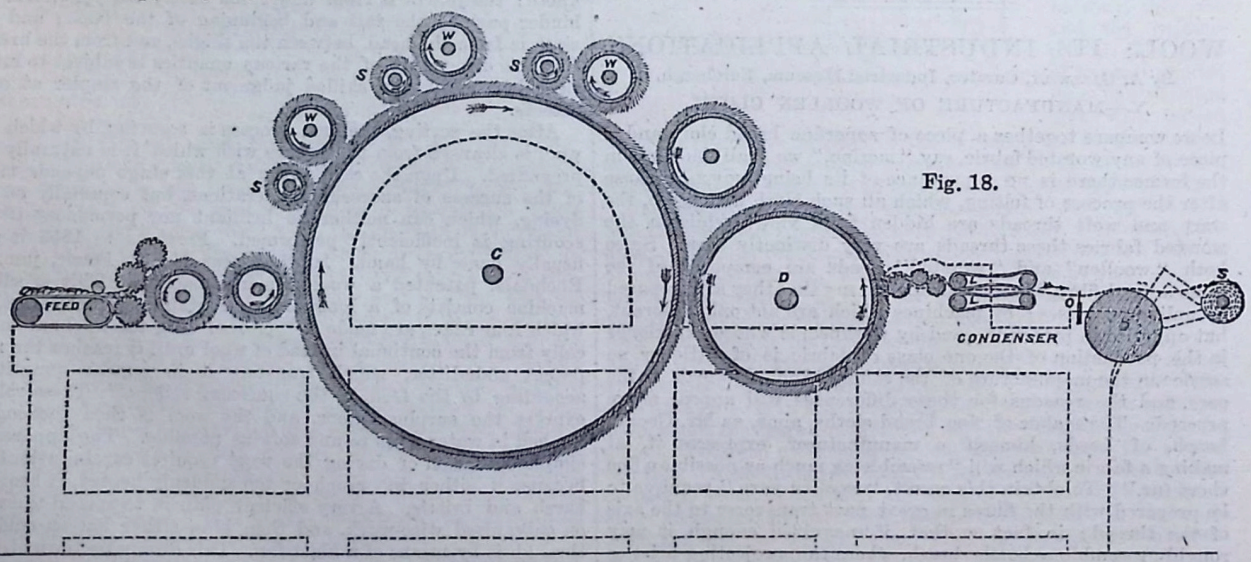


Fig. 18.

second series of rollers, and delivered by them to a second comb cylinder, which is stripped like the first; the strips are deposited on a grid, which allows the burrs and impurities to fall through, but retains the fibre to be transferred by a series of vibrating combs to the rollers and re-charged upon the cylinder until it is freed from all foreign matter. The burrs and other impurities are thus dropped through the grid to the floor."

At this stage, in order to remove harshness and give it greater elasticity to undergo the spinning processes, the wool is sprinkled with oil; and afterwards in the same machine it is what is called

machines will be understood by examining Fig. 18, which is a simplified longitudinal section of the last carding-engine and condenser. It consists of a large cylinder (C), surrounded by a number of small rollers called "workers" (W) and "strippers" (S). There is also a doffing cylinder (D), and one or two others. All these are covered with cards or brushes of wire, the points of which on the main cylinder and on the workers incline in opposite directions, so as to card the wool by opening, mixing, and blending the fibres till they form one thin, continuous, uniform sheet or flake of wool. In the case of the strippers or

cleaners, the teeth move in the same direction as those on the workers and cylinder, so as to clean or "float" off the wool from the worker and deposit it again on the cylinder. Fig. 19 shows the relative position of the teeth on the workers and main cylinder, and Fig. 20 those of the strippers and workers. These two figures also show the angle at which the carding teeth are set, and Fig. 21 shows how they are fixed into the leather or india-rubber which covers the rollers. The three carding-engines have their teeth formed of wire of different sizes, the first being the coarsest and the last the finest. In some of the newer sets of engines there are on the first 500 points to the square inch, on the second 600, and on the third 700. Not more than one-eightieth to one-ninetieth of an inch of space intervenes between the card-surfaces of the cylinder, workers, and doffer, from which an idea can be formed of the great nicety required in adjusting the various parts of a carding-engine.

When the carded fleece reaches the doffer (D), which, with the exception of some recently-introduced kinds, has its card-surface divided into a number of strips or parallel rings with spaces between them, it is then acted upon by the *condenser*, so called from its forming the wool into slubbings before leaving the carding-engine, instead of this being done by a separate machine, formerly in use, and termed a "slubbing-billy." In Fairbairn's condenser, which is the one indicated in Fig. 18, the fleece is divided by thin steel blades as the doffer revolves towards them. These strips are caught by small grooved rollers, and carried forward between two endless sheets of leather or rubbers (L, L), which are stretched on pairs of rollers hung in frames, having a transverse alternate motion which rolls the strips into "slivers" or "slubbings." These condensed slivers—the first form of the yarn—each pass through separate wire loops (O) over a wooden roller, and are wound on two rows of bobbins or spools,

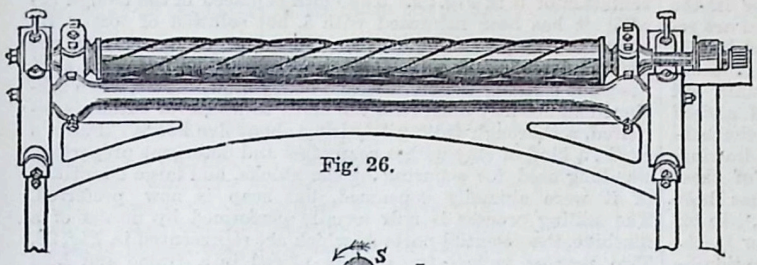


Fig. 26.

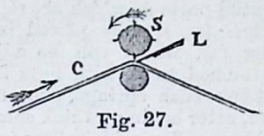


Fig. 27.

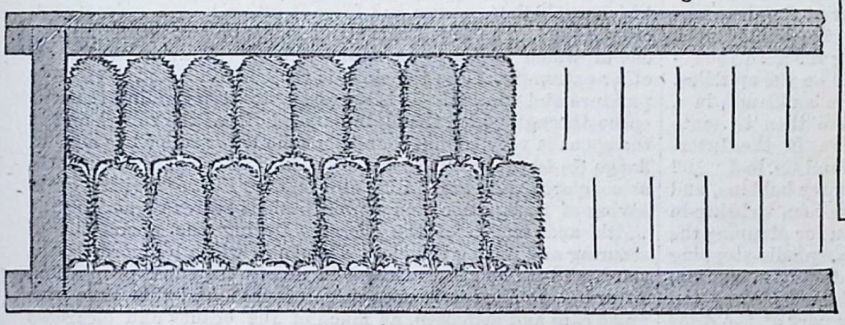


Fig. 25.

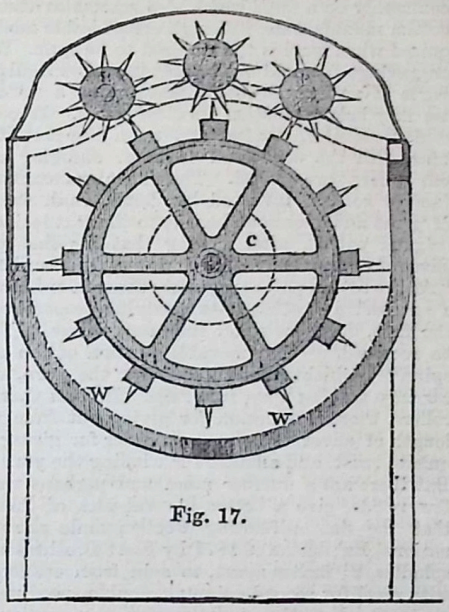


Fig. 17.

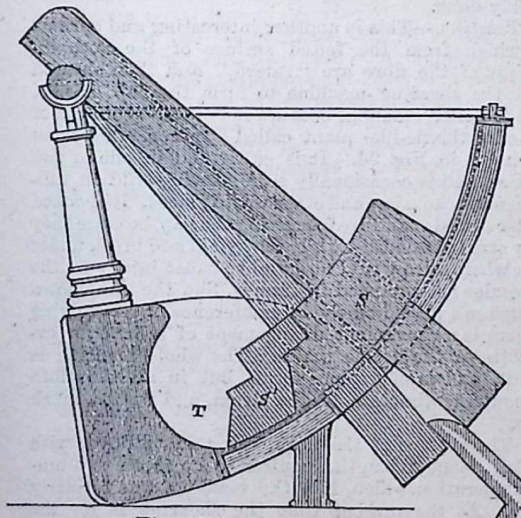


Fig. 22.

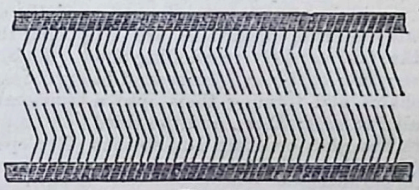


Fig. 19.

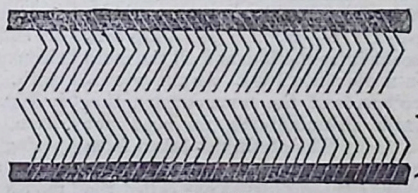
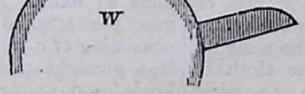


Fig. 20.

Fig. 24.



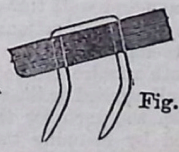


Fig. 21.

of which, however, only one (S) is shown in the figure, the other being situated right below it. The dotted line (Fig. 18) shows the course of sliver on the condenser. Some condensers divide the fleece into as many as 120 slivers.

Spinning.—Woollen yarn is sometimes spun on a machine resembling the throstle used in spinning cotton, but much more commonly on a *mule* which also resembles those in use in the cotton manufacture, although considerable modifications are required when wool is the material to be spun. Without elaborate engravings it would not be easy to make intelligible the different parts of so complicated a machine as a self-acting mule, but we may briefly mention its chief parts. It consists of a *fixed and a movable portion*, and upon the first of these the bobbins, with the condensed sliver or slubbing and the drawing-out rollers, are placed. The ingenious construction of these famous rollers, invented by Louis Paul, in 1738, has been of great and enormous benefit to the textile industries. In his original patent, after stating that the first pair draw in the sliver of cotton or wool, he thus clearly describes their action:—"As the cotton passes regularly through or betwixt these rollers, a succession of *other rollers, moving proportionally faster* than the first, *draw the sliver* into *any degree of fineness* that may be required." The movable portion of the mule carries the spindles, which twist and receive the yarn, and is a sort of carriage moving upon iron rails. Besides that of the drawing-rollers, there is a motion for giving out from the bobbins the length of sliver to be spun, another for giving the yarn the requisite twist, and another for winding the yarn on the spindles. But there are a number more, and perhaps we could not, in a few words, give a better general idea of these than to state that the fine self-acting woollen mule shown in the International Exhibition of 1871 by Platt Brothers and Co. had "192 spindles, $2\frac{1}{8}$ inches apart, to spin from condenser bobbins, and with creel for second spinning, double-speed motion, twisting-in or drawback motion, twist motion, stop motion for stopping the mule, governor and quadrant regulating motion, spindle-stopping motion, positive cam-shaft motion, friction taking-in motion, long copping rail and double copping or shaper plates, and motion for putting the double speed on at any part of the draw or stretch."

Winding, Warping, and Sizing.—These operations are all done upon special machines; the first consists in winding the yarn from the mule cops on "warper's bobbins;" the second in taking the yarn off these bobbins and forming them into a "warp" with the threads parallel to each other; and the third in sizing the warp threads with hot glue or other size so that they may have strength enough to bear the tension to which they are subjected in the loom.

Weaving.—On account of the comparatively slight twist which is given to woollen yarn—thus enabling it to felt easily—it is more difficult to weave in the power-loom than worsted, cotton, silk, or linen. Power-looms for woollen goods are consequently of comparatively recent introduction, and all the more important advances have been made since 1851. As the power-loom employed in weaving woollens is of the same construction as those used for other textile manufactures, we need not attempt to describe its details here. The cloth just taken from the loom is called the "raw thread," and has still to pass through the felting and afterwards through what are called the finishing processes. At this stage, as has been already explained, woollen cloth shows the warp and weft threads as well as a piece of worsted fabric. Subsequent operations, however, totally change the appearance of its surface.

Scouring.—The newly-woven cloth requires to be scoured or brayed in order to remove both the oil applied to the wool before carding, and the size used to stiffen the yarn for the weaving process. The scouring is effected by steeping the cloth in alkaline liquor, and beating it in the fulling stocks or passing it between heavy rollers. Afterwards it is put through clean water, dried, and examined by the *burler*, who carefully removes any knots or burls, and rectifies any imperfections in the weaving.

Milling or Fulling.—This is one of the most interesting of all the processes carried on in a woollen mill. By it, through the combined action of heat, friction, and moisture, the cloth is *felted*, that is, the fibres of the wool, by reason of their minutely jagged or serrated edges, interlock or hook into each other, thereby strengthening, thickening, and forming, as it were, a new matted surface on the cloth. The old way of both scouring and milling, now almost entirely gone out of use, was by the "fulling stocks," which consist of heavy woollen mallets driven by cog-wheels after the manner of tilt hammers. As this machine, from the great length of time it has been employed in our woollen factories, has an historical interest, we give a representation of it in Fig. 22. The cloth is placed in the trough (T) after it has been saturated with a hot solution of soap. By means of the projecting cogs on the wheel or barrel (W), the two ponderous mallets (S, S′) alternately rise and fall, each as it descends striking the cloth with a heavy blow. This, when continued sufficiently long, felts the cloth to whatever extent is required, a thorough fulling requiring about five hours. Fuller's earth, a kind of clay with a soapy feel and detergent properties, was long used for scouring by the stocks, and large quantities of it were annually consumed, but soap is now preferred. The milling process is now usually performed by means of a machine, the essential parts of which are represented in Fig. 23. Two narrow rollers (R, R′) are placed in a frame and held down by a spring (S), which can be adjusted by means of the rods (A, A) attached to it, with nuts at their lower ends. There are in fact two such springs, one on each side of these rollers. The cloth, after having a thick solution of soap applied to it, is conducted by smaller guide-rollers (G, G) to those at R, R, which apply the pressure and force it into a long narrow trough or spout (T). The top of this spout hangs on two spring hinges, one of which is shown at Z, and weights (W) are placed at its other extremity. Here the cloth is further submitted to yielding pressure and friction. It is necessary to keep in mind that the space through which the cloth passes both at the rollers and in the spout is very confined, and that the lower roller has a metal flange (C) to prevent it spreading. This kind of milling machine, as compared with the fulling stocks, does its work with a great saving of time, space, and power, besides better regulating the width and length of the pieces. During the operations of scouring and felting the cloth shrinks in width by more than a third, and its length contracts in nearly the same proportion. After being milled it is once more scoured, and this time with great care and attention, as much of the beauty and clearness of the colour or colours in the finished fabric depend upon its being thoroughly done.

Raising or Teazling.—This is another interesting and curious process, by which from the felted surface of the cloth innumerable points of the fibre are "raised," and then sheared or cropped in the shearing machine to form the nap or pile. The operation is called teazling, because it is done by means of the ripe head of a thistle-like plant called the teazle (*Dipsacus Fullonium*), shown in Fig. 24. It is cultivated in one or two English counties, and is occasionally seen growing wild on railway embankments, roadsides, and other waste places. Its hooked scales are better suited than wire for raising the nap, because they are sufficiently strong to do this, while they yield and break under circumstances where wire would not, and so cause injury to the cloth. The teazles are arranged in frames, like the one shown in Fig. 25, which are placed on the circumference of a revolving drum, and there is a convenient arrangement of rollers for exposing the cloth to the teazle scales. The whole machine is called a gig-mill, and is of various forms, but in all the cloth moves in a contrary direction to the drum, and with a much slower motion.

Shearing.—The surface of the cloth, being now all over with raised points of unequal length, requires to be shorn to a uniform level, an operation which, like the teazling, was formerly done by hand. At the present time the shearing is for the most part effected by means of a machine called a "perpetual," consisting of a roller with cutting blades passing spirally round it, a straight piece of steel with a fine edge called a ledger blade, and an arrangement of rollers by which the cloth is brought up against the shearing blades, with proper driving-gear to set the whole in motion. Fig. 26 shows a face-view of the cutting portion of the machine, and Fig. 27 a cross-section of the same, in which S is the spiral cutter, L the ledger blade, and C the cloth. As the spiral revolves, it, together with the straight fixed blade, acts like a pair of scissors, and cuts the nap of the cloth to the desired length. Of course, in a machine doing delicate work of this kind the several parts must be very carefully adjusted, for which purpose the bearings are made compensating, and are so constructed that if the ends of the

cutting roller, for example, should wear unequally the bushes in which its ends rest, it swivels or adjusts itself so as to prevent irregular cutting. In like manner, if either the straight or spiral cutter should wear more at one side of the machine than at the other, a similar compensating action takes place. Cloth is usually "raised" twice and "cropped" several times, but the extent to which these operations are carried varies according to the nature of the finish the cloth is to receive.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXVIII.—PROFESSOR SIR CHARLES WHEATSTONE.

CHARLES WHEATSTONE, the scientific inventor of the electric telegraph, was born at Gloucester in 1802. In early life, his being engaged in the manufacture of musical instruments led him to study the laws of sound; some of his experiments on acoustic figures were presented to the Royal Society in 1833, and subsequently to the Royal Institution. Next year he applied himself to the investigation of light and electricity, and experimenting upon their velocity and duration; and in the same year he was appointed Professor of Experimental Philosophy in King's College.

In 1838 Professor Wheatstone submitted to the British Association his stereoscope, the instrument invented by him for illustrating the phenomena of binocular vision. His paper was considered by Sir David Brewster to be one of the most valuable optical papers presented to the Association; while Sir John Herschel regarded Mr. Wheatstone's discovery as curious and beautiful for its simplicity. It is described in the *Philosophical Transactions*, part I., pp. 373-376, and may be thus simplified. When we look at any round object, first with one eye, and then with the other, we discover that with the right eye we see most of the right-hand side of the object, and with the left eye most of the left-hand side. These two images are combined, and we see an object which we know to be round. The instrument consists of two mirrors placed at an angle of 45 degrees, or of two semi-leaves turned with their curved sides towards each other. To view its phenomena, two pictures are obtained by the camera on photographic paper of any object in two positions, corresponding with the conditions of viewing it with the two eyes. By the mirrors or the lenses these dissimilar pictures are combined within the eye, and the vision of an actually solid object is produced from the pictures represented on a plane surface.

We now pass on to the invention of the electric telegraph. In 1819 Oersted made his grand discovery of the deflection, by a current of electricity, of a metallic needle at right angles to such current. Dr. Hamel, of St. Petersburg, states that Baron Schilling first applied Oersted's discovery to telegraphy; it is also claimed by Ampère, but his plan was very complicated; and Schilling first realised the idea by actually producing an electro-magnetic telegraph simpler in construction than that which Ampère had *imagined*. In 1836, Professor Muncke, of Heidelberg, who had inspected Schilling's apparatus, explained the same to William Fothergill Cooke, who in the following year returned to England, and, simultaneously with Professor Wheatstone, laboured for the introduction of the electro-magnetic telegraph upon the English railways; the first patent for which was taken out in the joint names of these two gentlemen, in the year 1837, and laid on the London and Blackwall Railway. The wires employed were of copper, enclosed in an iron tube, each wire being separated from its neighbour by some non-conducting material.

In 1844 Professor Wheatstone, with one of his telegraphs, formed a communication between King's College and the lofty shot tower on the opposite bank of the Thames; the wire was laid along the parapets of the terrace of Somerset House and Waterloo Bridge, and thence to the top of the tower, about 150 feet high, where a telegraph was placed; the wire then descended, and a plate of zinc attached to its extremity was plunged into the mud of the river, whilst a similar plate, attached to the extremity of the north side, was immersed in the water. The circuit was thus completed by the entire breadth of the Thames, and the telegraph acted as well as if the circuit was entirely metallic.

Meanwhile, a misunderstanding arose as to the relative positions of Messrs. Cooke and Wheatstone, in connection with the invention; when Sir Marc I. Brunel and Professor Daniell awarded Mr. Cooke to stand alone as to the practical introduction of the electric telegraph, and Professor Wheatstone as the scientific man whose remarks had prepared the public for the practical application. But the document was misinterpreted, and related only to Cooke and Wheatstone's first patent; whereas the investigations were mostly carried out by Wheatstone; and under Cooke's superintendence, a telegraphic line of fourteen miles had already been laid down upon the Great Western Railway.

A submarine electric telegraph was, from the commencement of Mr. Wheatstone's experiments, a prominent object in his thoughts, as proved by letters, in 1837; he was examined by a Parliamentary Committee in February, 1840; and in the same year he showed his plans to some of the most distinguished scientific men in France. Mr. Cooke and Mr. Wheatstone then entered into partnership, from which Mr. Cooke subsequently retired, and the subject was for a time in abeyance; but five years afterwards it was taken up from Mr. Wheatstone's starting-point, and was successfully carried out. Vice-Admiral Smyth bore testimony to Professor Wheatstone's claim of eighteen years, as "the first contriver of the electric telegraph in the form which made it available for popular use." M. de la Rive attests Mr. Wheatstone to be the first to give electro-telegraphy the practical character that it now possesses; he adds, "This illustrious philosopher was led to this beautiful result by the researches that he made in 1834 upon the velocity of electricity—researches in which he employed insulated wires of several miles in length, and which had demonstrated to him the possibility of making voltaic and electro-magnetic currents to pass through circuits of this length." In an account of the laying of the cable in the *Times*, in 1866, it was emphatically declared, "The credit of the original idea—that is, of the invention itself—belongs to Mr. Wheatstone." There is also evidence of his having "privately revealed and demonstrated his invention of telegraphic communication, and not only foretold but proved the wonders it would accomplish."

The telegraphs used in this country, where signals are transient, and must be read off one by one as they appear, are the double and single telegraphs of Cooke and Wheatstone, used by the Electric Company and the South-Eastern Railway Company—the single needle requiring one wire, and the double needle two. The telegraph of Professor Wheatstone, in which a hand points to the letter itself on a dial, is gaining ground for private use.

"The nerves of London" is the term applied to the system of wires which may be seen stretching across the sky-line of great thoroughfares, and visibly triangulating the metropolis in every direction. The battery employed to transmit the electric impulse along these delicate threads of copper is a form of the magneto-electric machine—one of the most beautiful of Faraday's splendid gifts to science. By rapid rotation, such a removal and replacement of a piece of iron before the poles of a magnet can be made, as to produce a series of electric impulses along a wire coiled around it; and electric impulses of this kind can be produced from a very small magnet, which yet possess sufficient power to work the delicate instruments, even after traversing a very considerable length of the ordinary coarse iron wire, or even miles of the extremely fine copper wire now used by Professor Wheatstone in his new cables. This system of wires may be seen vexing the eye at St. Clement Danes and St. Mary-le-Strand, the conducting wires being strained from poles on the house-tops.

The area of London being divided by a system of triangulation, the posts that form the meeting-points of three series of cables become the centres at which these multitudinous wires have to be distributed, at intervals carefully selected.

THE LATHE.—XVII.

By HENRY NORTHCOTT.

LATHES FOR SPECIAL PURPOSES (*continued*).

THE lathe given at Fig. 111 will show the different forms which lathes will take even when designed for similar purposes. This lathe is by the same eminent makers as the last described, and for the same class of work. But the last was capable of turning out only one wheel-tire at once, whereas this one

works upon two simultaneously, and as one man can attend to the double lathe a saving of labour is effected. This lathe, however, is adapted to the double purpose of boring out the tires and turning up the axles upon which the wheels are afterwards mounted. It differs in arrangement as much from the previous lathe as from ordinary self-acting lathes, inasmuch as in this example the cone-headstock is a very small affair, although fitted with the usual cone and double gearing. The spindle hitherto called the lathe-spindle, upon which the cone-pulley is mounted, is no longer the lathe-spindle, and instead of being raised above the bed, is actually below it. This spindle is in fact continued outwards through the bed, and it is furnished with pinions which drive the two face-plates to which the tires are seen attached. The axle of the face-plate is actually the lathe-spindle, and this is placed in the middle of the bed.

If the lathe were intended to bore tires only, no screw headstock would be needed any more than in the last case, but the two headstocks seen, and which convert the machine into a double complete lathe, are necessary when it is employed in turning the railway axles. The slide-rests are constructed in the ordinary manner, but it will be seen they have very little distance to travel, and the traverse of the tool is effected by a ratchet-wheel and lever. It should be understood that railway wheel-tires are bored out in order that they may be placed upon the central part of the wheel. Generally the wheel is a solid forging or casting, and this is bored out to fit fast upon a wrought iron or steel axle, and the face of the rim of the wheel is also carefully turned up in a suitable lathe to a size determined by a gauge. The tires are sometimes of high class wrought iron and sometimes mild steel. They are now usually made without a weld—that is to say, the iron is rolled whilst hot, and in a suitable machine, into a complete ring of the proper section and size, and in this form and state it comes into the hands of the turner, who has to turn or bore out the inside of the tire to a size *slightly* less than the wheel-blank upon which it is to be fixed, and also to face up one edge of the tire. The difference in size between the wheel and tire is a matter of great importance, but this is not determined by the turner, who has a gauge given him, and to this he must be careful to work. After the tire is bored it and the wheel-blank are taken to the forge, where the former is heated in a clear fire on a special hearth to a very low red heat, or scarcely so hot, but this temperature is sufficient to cause the metal to expand and the ring or tire to become perceptibly larger—large enough, when taken from the fire, to allow of its being slipped upon the previously too large wheel. A little water is now sprinkled over the hot tire, which latter when cooling endeavours to return to its original size, and when cold, if the operation has been properly conducted, the tire is found immovably shrunk on to the wheel.

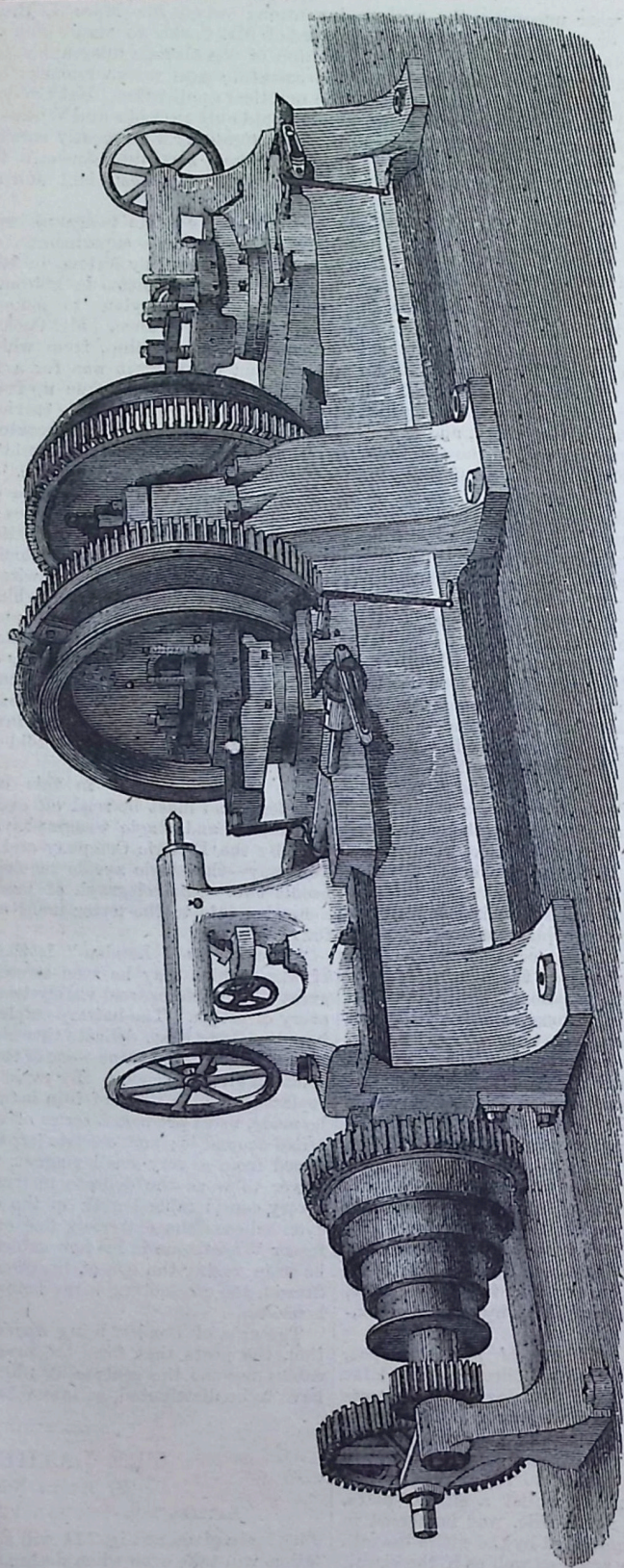


Fig. 111.—LATHE FOR BORING OUT INSIDE OF RAILWAY WHEEL-TIRES, BY MESSRS. FAIRBAIRN, KENNEDY, AND NAYLOR.

The first object of the tire-boring lathe will be now seen, but the lathe under notice is also designed for turning up railway axles, an operation which is thus performed:—The wheels being bored out to a certain size, the axles require to be turned down to the same diameter; but the fit of the wheel upon the axle is an extremely tight one. Indeed, it is so much so that hydraulic pressure is now very generally employed to force the wheels on and off their axles. Two necks or bearings have also to be turned in the axles, one at each end, and the extreme ends have to be faced up. All of this work, it will be observed, has to be performed upon the ends of the axles only, and there is no necessity to touch the middle part of them if the rough bar be carefully centered and straightened. If the axles were turned up in an ordinary lathe, the workman would operate upon and probably completely finish one end of the axle at a time, as one end would be required for the lathe-carrier. But as it is not required to turn the middle of the axle, it becomes possible to operate upon both ends simultaneously, provided some means can be devised for driving the axle from the middle instead of from the end. And this is one of the objects of Messrs. Fairbairn

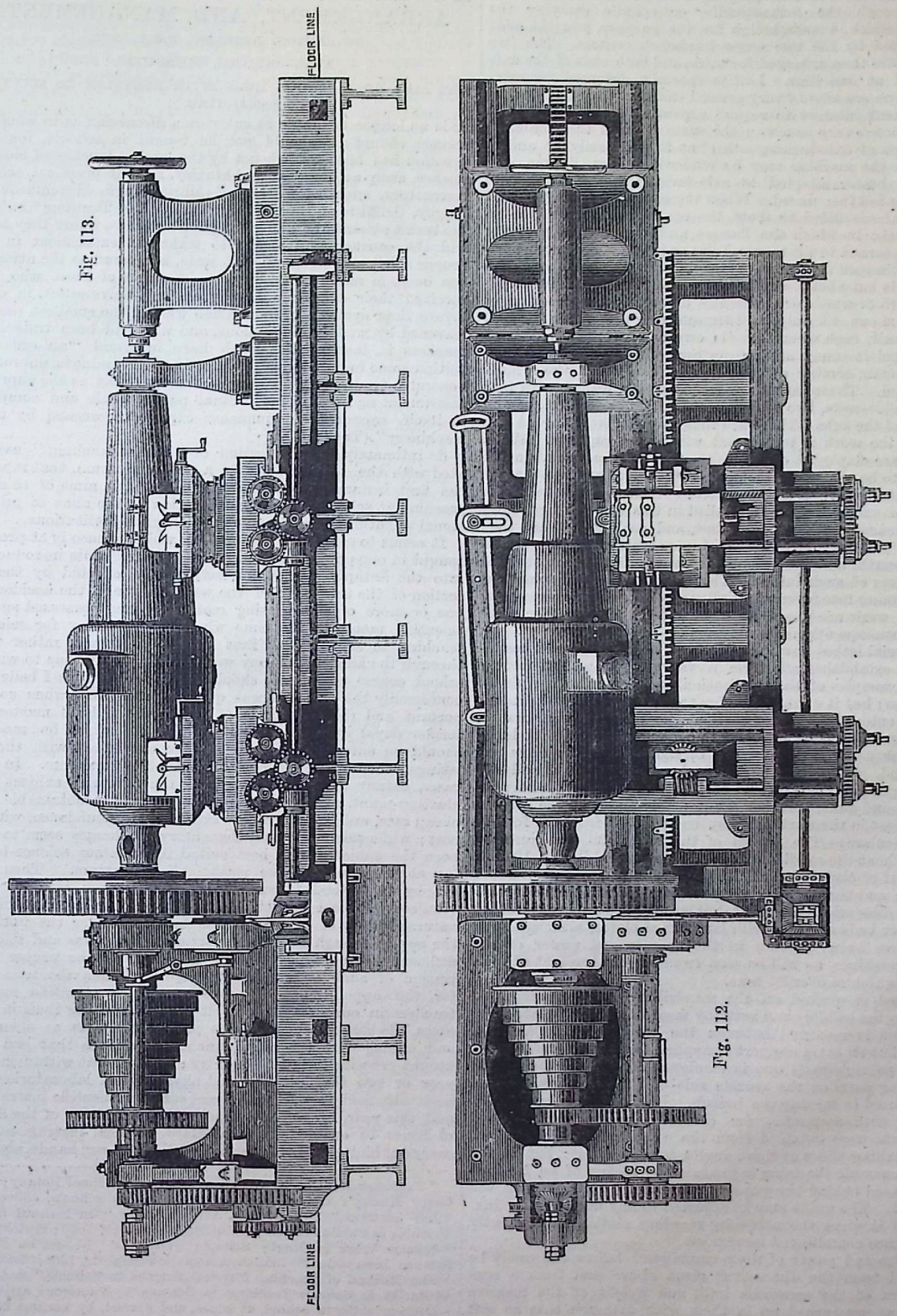


Fig. 112 (PLAN) AND Fig. 113 (ELEVATION).—SPECIAL LATHE IN USE AT WOOLWICH ARSENAL FOR TURNING-UP 600-POUND GUNS.

and Co's lathe. The axle properly centered and straightened is put through the lathe-spindle, or spindle carrying the face-plate, which is made hollow for the purpose, and the ends are supported by the two screw headstock centres. The two slide-rests are then arranged for work, and both ends of the axle are turned at one time. Lathes specially designed for axle-turning alone are also in very general use, but they do not present sufficient interest to require separate illustration. They are constructed very much on the same plan as the combined tire-boring and axle-turning lathe, but it will easily be understood that the machine may be rendered neater, lighter, and altogether better adapted to axle-turning if the tire-boring power were not introduced. When these axles are turned, and the two wheels fitted to them, the complete axle is taken to another lathe in which the flanges and conical treads of the wheels are turned to the required size and form. Railway wheel-turning lathes are very massive machines, in which the axle with its wheels is hung between the centre points of two heavy headstocks, both of which are generally driven, so that instead of driving from one end only, and transmitting the power through the axle itself, each wheel has its own driving-plate and arms which impel it round against its own cut, and without any torsional strain coming upon the axle upon which the wheels are mounted. These lathes are frequently furnished with four complete slide-rests, two of which operate on each wheel, one on each side of the axle. There are thus four tools acting at one time, and the work is turned out with great rapidity. When two tools are employed on opposite sides of the work, one of them has to be placed upside down as it were, because the cut comes to the tool from below, instead of from above as in the ordinary manner. Two tools applied in this way are frequently fitted to ordinary self-acting lathes, and such lathes are then known as "duplex" lathes. The duplex system originated with Mr. Whitworth, and Sir Joseph Whitworth and Co. are still the chief makers of such lathes. The system has been somewhat slow in coming into favour for ordinary work, but its advantages for heavy work are unquestionable, and its adoption for large lathes is consequently more universal.

The special lathes now in use in large engineering and manufacturing establishments form a very large and interesting series of examples of the application and extensive usefulness of the lathe; but it would be foreign to the purpose of the present papers to enter with greater particularity into this large branch of turning. It will be sufficient to conclude the notice of large lathes with a description of one of the finest of its class yet constructed. Several of the lathes shown at Figs. 112 and 113 were designed and constructed at Woolwich Arsenal for turning up 600-pound guns, and they are probably amongst the largest and heaviest in the world, as may be gathered from the following particulars:—The length of the bed is 36 feet, and the width without the saddle-bed 6 feet, with the saddle-bed 10 feet. The height of centres is sufficient to receive a diameter of 8 feet 6 inches; and the diameter of the face-plate is 7 feet 8 inches. All these dimensions are great, but lathes have been constructed with larger beds and also with larger face-plates, although such lathes have been wanting in the solidity and power of the present machines, as will be seen from the total weight of each of them, which is over 84 tons.

The feed is worked off the mandril by direct gearing, and applied to the saddles and rests by means of friction-plates.

The gun is mounted between the headstock in the usual manner, but an extra support is applied to it at the muzzle end. Of the two slide-rests one is employed to produce the conical or tapering parts on the muzzle side of the trunnions, and the other is used in turning the breech. In a previous example of a lathe with apparatus for conical turning, the required movements were obtained from the combined motions of two screw-working slides at right angles to each other; but in the present example the taper is produced by means of an inclined guide placed behind the gun and connected by a link with the slide-rest. The guide may be adjusted to any moderate inclination, and it gives the necessary receding motion as efficiently as the more complicated mechanism.

The size and power of these magnificent lathes can easily be imagined from the dimensions given above, and from a consideration of the enormous bulk and weight of the massive guns that are turned up in them with as much ease as soft wood in an ordinary lathe.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XVII.—SCHOOL MUSEUMS.

THE AIMS OF A SCHOOL MUSEUM IN RELATION TO SCIENCE-TEACHING.

It is no longer desirable to enter on a discussion as to whether science should or should not be taught in schools, for the question has been settled, not by the mere advocacy of men of science, such as Henslow and Huxley, and of practical school instructors, such as Farrar of Marlborough, Hutchinson of Rugby, Griffiths of Harrow, and Tuckwell of Taunton,* but by the result attained at our great public schools, where they have had the courage and means to make the experiment in the proper spirit and on a sufficient scale, hampered as the attempt has been, in many cases, by the opposition of those who had received their education in our ancient universities, in days before their systems of instruction were in the smallest degree leavened by modern innovations, and who had been trained as teachers in institutions which have inherited "an order of tuition some hundred years old, fortified with minute, unbroken, venerable traditions, looked upon for ages past as the supreme instrument and test of intellectual power, whole and complete in itself, supported by immense experience, worked by tried machinery" (Tuckwell).

So intimately is the question of "science-teaching" associated with the requirements of a school museum, that it is, in the first instance, necessary to consider the aims of science-teaching at schools, in contradistinction to the aims of professional scientific instruction at our collegiate institutions.

It seems to me that the manner in which science is at present taught in our public schools, gives evidence of its introduction into the antique curriculum having been effected by the insertion of the thin edge of the wedge, through the accident of one or more of the existing masters having possessed special scientific tastes, at the time when the necessity for science-teaching in schools was first publicly discussed, rather than through the adoption of any well-digested scheme as to what a school course on science should embrace; and this I believe is confessedly the case. It was quite natural that when so important and (to the minds of most of the head masters of former days) questionable an experiment had to be made it should be entrusted to those already conversant with the existing method of the schools, rather than to strangers. In such cases, botany seems to have been the favourite subject for a starting-point, as good diagrams were readily obtainable at a cheap rate, and specimens are attainable in abundance, without cost; while astronomy and elementary mechanics seem to have been the subjects next best suited for amateur science-teaching at the hands of the mathematical masters. Then geography was extended from the old dry groove into its more vitalised physical aspect, so that a certain amount of the natural history of our earth was brought under the notice of the pupils, though in this department there was and still is a deficiency of suitable teaching material for the proper illustration of such an important subject. When the time came for the appointment of properly *trained* scientific men as teachers in our great schools, it is not surprising that, in most cases, the successful candidates proved chemists, as chemistry and mining were the only branches of science that had been taught *practically* in this country; for it is but within the last year or two that physical and physiological laboratories have been attached to our recognised seats of scientific instruction, and this year, for the first time, will the students of the School of Mines be enabled to manipulate physical instruments and carry out biological investigations with their own hands, now that

* Professor Henslow's "Practical Lessons in School Botany;" Professor Huxley's various lectures on science in schools, collected in "Lay Sermons," 2nd edition, 1871; Farrar "On Natural Science Teaching in Public Schools;" British Association, 1866; Hutchinson's "Science Work in Rugby School;" Griffiths' "Report on Natural Science Instruction," British Association Reports, 1868; Tuckwell's "The Method of Teaching Physical Science in Schools," and "The Obstacles to Science Teaching in Schools." Numerous articles on science-teaching in school, at home, and abroad, by various authorities, are scattered through the volumes of *Nature*.

suitable arrangements have been provided at the new "Science Schools" at South Kensington. Even in those schools, which are the most advanced as to the method of science-teaching, no complete course on physics has as yet been given, nor has any serious attempt been made to give instruction in mineralogy or zoology, if the returns I have obtained from our public schools are perfectly correct, though human physiology has been, since the publication of Huxley's admirable "Lessons" and Marshall's diagrams, in a few instances taken up.

The most perfect school course on science I am acquainted with is that which was adopted at the Liverpool Collegiate Institution in 1854, by Dr. Birkbeck Nevins and Professor T. C. Archer. It comprised 13 lessons "on the general properties of matter," 6 on "mechanical powers," 16 on "hydrostatics and hydraulics," 10 on "pneumatics," 13 on "heat," 8 on "light," 7 on "magnetism," 11 on "electricity," 9 on "galvanism," 4 on "electro-magnetism," 1 on "thermo-electricity," = 98 lessons on "Natural Philosophy;" and lessons on the most important elements and their compounds and manufactures connected therewith, "chemical philosophy" and practical laboratory instruction to the extent of 100 on "Chemistry," which extended over two years, and were given to the senior pupils of the *classical and modern divisions* that constitute the upper school; 10 lessons on "economic zoology," 10 on "structural botany," 10 on "economic botany," 10 on "economic mineralogy" = 40 lessons on "Natural History in relation to Commerce," extended over one year, were given to the *modern division* of the school. The "classical division" being preparatory to the *universities*, the "modern division" provided a comprehensive education for *business*. Since Professor Archer's appointment to the Edinburgh Museum of Technology, the natural history course has been dropped, and at the present time rudimentary chemistry is taught in the lower school, and chemistry and natural philosophy in the middle and upper schools.

At Cheltenham College science is taught both in the classical and in the military and civil departments, and the entire course comprises botany, geology, physical geography, chemistry, light, heat, electricity, magnetism, pneumatics, hydrostatics, and mechanics. A museum is attached, which is open *one day* in the week to the collegians and one day to the public, and contains collections of mineralogy, botany, entomology, geology, illustrations of arts and manufactures, chemical, physical, and mathematical instruments, ancient and modern coins. At Rugby the course comprises botany, geology, astronomy, physical geography, chemistry, heat, electricity, magnetism, pneumatics, hydrostatics, mechanics, and physiology; instruction in practical chemistry is given in a well-appointed laboratory, "Harcourt and Madan's Practical Chemistry" and "Fresenius" being adopted as the text-books. In connection with this school is an astronomical observatory, wherein is mounted a magnificent equatorial telescope, formerly the property of Mr. Dawes, fitted with an 8½-inch achromatic object-glass by Alvan Clark, which is ultimately to be made the property of the school. This telescope is supplemented by half-a-dozen refractors and reflectors of large size belonging to the staff. A museum has also been established by the Rugby School Natural History Society (founded in 1867), mainly for the purpose of illustrating *local* natural history, which contains good and well-arranged collections of local plants, butterflies, moths, beetles, birds, fossils, etc., collected within a range of five miles radius by the members of this youthful society. This is supplemented by a carefully-selected series of minerals and a complete set of specimens to illustrate Professor Rollerston's "Typical Forms of Animal Life," to which a clear description of every dissection is attached. This society, it may be said to the credit of its members, has published five illustrated annual reports.

At Eton, beyond a little botany, natural history has not yet been attempted, except such as pertains to the subject of physical geography. Astronomy, heat, hydrostatics, mechanics are taught, but the principal subject is chemistry. Practical instruction in a well-appointed laboratory is given out of school hours to those who attend the chemistry course. It is to be regretted that in a school of this standing neither a museum nor a boys' society has, as yet, been established. An observatory has been erected on the roof of the western tower of the new school, in which has been mounted a refracting telescope of 5·9 clear aperture and 88 inches focus, under the superintendence of its makers, Messrs. Cooke of York. As this instrument was selected especially for the requirements of school instruction in practical astronomy, I may state that an interesting account of the telescope and its appliances is given by Mr. H. G. Madan, the science master at Eton, in *Nature* for January 6, 1870.

At Harrow science-teaching was established in 1865 under the management of Mr. Farrar, but this department is at present under the superintendence of Mr. G. Griffiths. As yet there is neither a laboratory nor a museum, and till suitable buildings are erected practical work is of a very limited character. At present three hours in each week are devoted to teaching experimental physics to the "modern side," and one hour in each week to the "classical side" of the school. The boys are required to make copious notes, which are examined and corrected by the master. Those on the modern side are occasionally required to repeat some of the experiments which have been shown during the lectures, and they are examined every fortnight, whilst the boys on the classical side are only examined every term. Comparative anatomy is taught in a practical manner on half-holidays to such boys as voluntarily enter the class. As early as 1864 an interest was manifested in this school for natural history by the publication of a Harrow *Flora*, with notes on birds, insects, etc., and in 1865 the Harrow School Scientific Society was founded, which has printed its reports from time to time.

At Marlborough College, science-teaching has only been in operation since 1870, under the superintendence of Mr. Farrar, late of Harrow. The subjects entered on have been botany, heat, and physiology, and the aim has been to teach each subject thoroughly, with the view of enabling the boys to compete for the science scholarships offered at our universities. As early as 1863, the Marlborough College Natural History Society was founded by the Rev. T. A. Preston, and as its aims and the rules adopted for its management are thoroughly practical, they have served as a guide to other similar school societies since established. This society has formed a museum, containing general collections of minerals, plants, osteological, anatomical, and physiological specimens, lepidoptera, birds and birds' eggs, but aims in future at making the museum more of a local character, when more room can be obtained, as much of its utility is destroyed through its being at present located in one of the class-rooms. This society has published a series of reports.

At Sherborne School they are only getting science-teaching into shape, and are busied in preparing proper buildings for the purpose. Lessons are given regularly in mechanics, geology, and physical geography, and the material for the foundation of a natural history museum has been collected. At the Countess of Harewood's school, near Leeds, Mr. Jones, the head master, taught science in a systematic manner, illustrated by specimens, as early as 1855. The York School, under the management of the Society of Friends, established a natural history society as early as 1834, which has an excellent local museum, regularly publishes its annual reports, and is still in unpretending operation, though it has sent forth many men whose names are now known in science. At present lectures are given once a week on chemistry, physics, physiology, geology, and astronomy to each of the divisions (senior and junior) of the school. Two hours a week are devoted to practical class teaching, recapitulations, and examinations; an astronomical observatory is fitted with a transit instrument and a good 4½-inch equatorial telescope; and a workshop with lathes, fret-cutting machines, benches, tools, etc. Prizes are offered for natural history, "collecting," etc. Occasional lectures are given on general subjects by others than the staff.

At Taunton Collegiate School physical geography, botany, human and comparative physiology, and chemistry are taught. Physics is taught in a well-filled museum, which also serves as a lecture-room; practical chemistry is taught in a small laboratory, mechanics in a workshop, and to aid the practical botany class half an acre of ground is laid out with about 250 plants. In this garden there is an observatory, with a set of meteorological instruments, the records of which are published in the Registrar-General's reports. In this school science is made compulsory on all boys above the lower school, and it takes rank with other school work, and involves no extra charge.

At the City Middle Class School, the first established by the Middle Class Schools Corporation "to provide such an education

as shall prepare the scholar for the industrial and commercial work of life, and such as shall not have the effect of excluding any of the classes for whose benefit the schools are founded," for the almost nominal terms of one guinea per quarter, two or three branches of elementary physics and chemistry are taught in the upper division, together with practical chemistry in the laboratory; but I have not received any detailed statement from this school of the actual work done therein. At present, both lecture-theatre and laboratory are on a small scale, but the head master is seeking subscriptions both from the governors of the Corporation and the parents and friends of the pupils, towards a fund for the erection of, *primarily*, a *large* hall, capable of holding 1,000 adults and 500 boys, wherein the head master and others may, on the occasion of the distribution of prizes and on other contemplated "occasional gatherings of boys' parents and of friends and patrons," be able "to address *all* its numbers assembled;" *secondly*, for the erection of *a small lecture-room*, connected with a laboratory, where 50 boys at a time could study chemistry practically, and another laboratory where physical science could be taught experimentally. In association with such science rooms, *a small museum* is *ultimately* contemplated. Considering that the City Middle Class School will be the model for all other schools, presently to be opened by the Corporation in other parts of London and its suburbs, it is to be regretted that the contemplated *science buildings* have not been considered of *primary* importance, wherein a lecture-theatre capable of holding 1,500 persons would also have met the requirements of the contemplated *occasional* gatherings of masters, pupils, friends, and patrons, and provided a fitting shrine for "that *genius loci*" which should ever be associated with a great public school.

From the examples cited it is evident a great amount of good and earnest science-work is being carried on at the present moment in our public schools, but upon no definite system, with too prominent an absence of instruction in general natural history (an excellent medium for conveying elementary information as to the nature of the objects that surround us on every side, and provide the necessaries for our very existence from day to day) and a deficiency of teaching material—collections of *objects, as belonging to the schools themselves*, being an exception, through too great a reliance being placed on cheap diagrams, which can never take the place of actual specimens, any more than the actual observation of physical phenomena can ever be supplanted by book-knowledge, be descriptions ever so graphic, if instruction in science is intended to stick, as stick it will, and for a life-time, if a teacher will but employ demonstration as well as assertion. There is a vulgar saying that "there is nothing like leather;" well, I fancy those specialists who have been appointed as science masters to our great schools, have, as a rule, put too great a faith in their adopted subjects, and have devoted their energies to making the boys under them expert botanists, chemists, or physicists in some special department, rather than trying to impart that amount of elementary scientific knowledge which *every* educated man should possess—knowledge which could not be designated as "superficial," and which could always be supplemented with a greater or less amount of advanced instruction in such departments of science as would prove of most advantage in the professional future of a boy. This, I think, should be the *primary aim* of science-teaching in schools, as it involves that kind of training of all the senses which, confessedly, neither classical nor mathematical teaching touches—viz., *observation* of objects, phenomena, and the results of experiment, which necessitates the acquisition of that precise *terminology* whereby all observations may be definitely expressed or recorded in a language common to all naturalists, and inculcates a habit of keeping the faculties alive and the eyes open, not merely for the things that lie in our path, but for those that may be hidden in nooks and corners of the earth, under the waters, or in the sky above our heads.* *Comparison* (which Huxley has well defined as "the process of tying up similar facts into bundles, ticketed ready for use," under the name of "general propositions") provides good exercise for the discriminating powers, and lays the basis for a due appreciation of the orderly arrangement of the results of comparison—viz., *classification*, and of methodical description associated therewith, termed *physiography*.

To the inquiry, "What elementary course would provide the amount of information and the kind of training indicated?" I would answer, a complete course on natural history; for does not mineralogy—that much-neglected science in a country abounding with mineral wealth—provide material for instruction in the most important chemical, structural, crystallographic, physical, acoustic, optical, thermotic, electric, magnetic, organoleptic, and crystallogenetic (the equivalent of embryological character in organic nature) characters of inorganic bodies, as a necessary prelude to instruction in the morphological and physiological characters of plants and animals? and, as Huxley says, "systematic teaching in biology cannot be attempted with success until the student has attained to a certain knowledge in physics and chemistry; for though the phenomena of life are dependent neither on physical nor on chemical, but on vital, forces; yet they result in all sorts of physical and chemical changes which can only be judged by their own laws."

* "To a person uninitiated in natural history, his country or seaside stroll is a walk through a gallery filled with wondrous works of art, *nine-tenths of which have their faces turned to the wall.*" (Huxley's lecture "On the Educational Value of the Natural History Sciences," at St. Martin's Hall, 1854.)

GREAT MANUFACTURES OF LITTLE THINGS.—XVI.

JEWELLERY (*continued from page* 310).

BY CHARLES HIBBS.

The ancient workers in precious metals made indiscriminately jewellery, drinking vessels, candlesticks, reliquaries, statuettes, and all articles of *vertu* in gold or silver, besides ornamenting armour and sinking dies for coins and medals. The minute subdivision of the arts which now prevails was then unknown, and the same Jewish artificer, Bezaleel, who set the twelve stones in the breastplate of judgment, and made the wreathen chains by which it hung, was also competent to work the fine gold threads into the linen of the ephod, and to construct the ark of the covenant and the mercy-seat of pure gold. Benvenuto Cellini made chalices and jewelled clasps for Pope Clement; and the English goldsmiths of the days of King Jamie were ready to turn out a necklace, a pair of earrings, or a service of massy plates, as the humour of their patrons served. The reason was that the processes of working were in all essential respects the same, whether the article were small or great; and even to this day, with all the changes in modes of production, plate-work is but jewellery-work writ large. As regards the *artistic* working of the precious metals, those changes have not been great from the earliest times, and the method followed now differs but little from that of the ancient workmen, who turned out their work by *embossing*.

Sir M. D. Wyatt thus describes the present mode of gold-working:—"Thus prepared"—*i.e.*, rolled into sheet—"the gold is ready for the goldsmith or jeweller, who commences beating it or twisting it into form, according to the nature of the object he would produce. Should he desire to execute embossed work upon it, he first, with a dry point, traces the subject he wishes to represent; then he beats it up, at first with a metal, but subsequently with a wooden hammer, into an approximative form, taking care not to reduce the thickness of the plate too much. He then proceeds to back up the concave side with a composition of pitch, wax, and brickdust melted together (a substance so tough as to be called by the mediæval writers 'tenax'), and upon the surface of the gold, thus equally supported, he continues to beat and punch until the desired relief and form are attained; then, with files, delicate chisels, gravers, and burnishers, he concludes by chasing up the more delicate details, and gets rid of the 'tenax' by heating it, until it runs out in a fluid state."

Compare this with Cellini's own account of the manner in which he worked:—"I will here speak of a gold clasp of a round form, which I made for Pope Clement VII., with which he fastened his mantle, and partly of the manner in which I worked it. . . . . Having made the model of the exact size of the intended work, I took a sheet of gold, larger by a finger all round than it would be when finished, and commenced bulging it in the middle, striking it with small hammers on the face of an anvil; but on the inside I struck it with the point of the

hammer, thus causing it to swell up very much in the middle; and where I observed that it was too thick I worked with the punches on either side, till the principal figure, that of the 'Father,' began to assume a suitable form. In this way, little by little, using all sorts of punches, with patience and enthusiasm, I made the gold plate obedient to me, and in a few days I very nearly got the figure of the 'Father' quite round."

He then describes how he fetched up the figures of the cherubs, "which were in number 15," and gradually detached them and the principal figure from the "field" of his work, bringing them out in entire relief, so that they only touched the groundwork here and there—a feat which the artists of his time delighted in. Thus finished, the clasp, which was only a hand's breadth, must have been a masterpiece of patience and ingenuity, as well as of art. It is much to be lamented that scarcely any of these works have come down to our time; the metal in which they were wrought was too conveniently valuable, and the cupidity or the exigencies of the owners often tempted them to sacrifice the glorious impress of the artist's genius for the sake of the medium that bore it. Clement himself is said to have melted down objects of art to the extent of 200 pounds weight of solid gold.

In the work just quoted from, the "Trattato dell' Oreficeria," Cellini also describes the practice of some of his fellow-artists. Speaking of Caradosso, he says:—"That most worthy artificer made, in the first place, a careful model in wax of his subject, and filling up with clay the under-cuttings, cast it in bronze; he then took a plate of gold, the thickness of which increased towards the centre, not so much, however, that he could not easily bend it, its width being also greater than that of his model. Having heated and worked the plate to a raised form, he placed it on the bronze model, and then hammered it with tools or punches made of birch or wild cherry, gradually causing the plate to take the form of the figures on the model, taking care, however, that the gold should not break, using his tools, whether of iron or wood, with great dexterity on either side of the plate, and always striving to render the gold of an even thickness throughout. The carefulness of Caradosso in this was very great."

The reader must not suppose from these descriptions that the art of metal-working, as practised in the jewellery manufacture of the present day, is of the slow, elaborate, and creative character belonging to the old masters. The plate of gold or other metal is still raised into relief, but it is done with the stamp and die, and the impressions from one design may extend to thousands of grosses. Any visitor to a modern jeweller's workshop, who expected to see the "cunning work" of the Italian artificers carried on in appropriate mystery and secrecy, would be cruelly disenchanted by the great heaps of "blanks," all of one pattern, which he would see lying before each workman, being advanced one little step at a time, with machine-like accuracy and monotony, not dwelt upon separately and lovingly until each became a "thing of beauty" and a "joy for ever." It is possible that these "blanks" (parts of lockets, bracelets, etc.) may be of some design registered by the manufacturer, and struck from his own die; but the greater probability is that they are what the trade calls "parish patterns," made by a jeweller's stamper, who is, perhaps, in a large way of business, employing many hands, and who sells these things to jewellers at so much per gross. The first thing which is likely to strike the visitor is the compact packing of the workmen, who seem almost as close together as soldiers on parade. Each sits down to his work, and the bench or table before him, whose rudimentary outline is half circular, has been scooped out to admit his body, so that he sits half enclosed, and is enabled to dispose his work and tools conveniently round him. In the centre of the hollow is a small wedge-shaped projecting piece of wood, called the "peg," on which he performs all his operations, and beneath is stretched a leather apron, or "skin," to catch the filings, and to serve as a convenient receptacle for tools. A board no larger than a common-sized dressing-table may have three holes, and accommodate as many workers, but some boards have four or five holes. A large shop will have a row of these boards down each side, and a double row in the middle, and thus as many as 100 men may be at work in a single room. In the centre of each board is the gas-jet which gives light to the whole group of workers sitting round it, and close to the right hand of each man is a little bent gas-pipe with open mouth, constantly burning, the flame of which he uses for soldering. The atmosphere of the shop after nightfall is consequently very warm and oppressive, but means are taken in the large and well-regulated factories to ensure good ventilation. Let us suppose that the work under progress is that of making lockets. The workman has a heap of backs, rims, rings, and other parts before him, and taking up a single "back," which in jeweller's parlance means either the top or bottom side of the locket, he fixes on it a rim in no time with a small pair of pliers, plasters round the joint very finely with moistened solder, and dives into the recesses of his skin for the "devil," which is a bunch of matted iron wire. Laying his work in the centre of this, he turns on his soldering-jet to the full, and with a blowpipe directs a stream of flame on to the whole surface, till the locket and the wire are both of a dull red. The two parts are one from that moment, and the metal would break in any other part as soon as in the joint. One half of the backs are fitted with rims just a thought larger in area than the others, in order that they may just wrap over and snap when the locket is closed. When he has provided them all with rims, and joined them together, he may proceed to affix the hinges. A delicate operation this to perform neatly, but his appliances are very complete. He has some lengths of very fine tube lying before him, and a little file, the round edge of which is exactly the size of the tube. He makes a little groove with this on the edge of one side of the locket, just in the centre, between the two halves, cutting through the rim to the substance of the two backs. Then he lays a length of the tube in the hollow, which fits in nicely, and measures off the length he requires, afterwards cutting it off with a fine saw. A piece of steel wire is next threaded through it, and two more cuts of the saw convert it into three pieces in a twinkling. These are again laid in the little groove, the steel wire withdrawn, a touch of solder is given to one side of the middle piece, and to the other side of the two end pieces, the flame is made to sweep over the joint, and all is fast in an instant. The locket is cooled by being turned into a basin of water; a little bit of wire is passed down the tube, cut off, riveted slightly at the two ends, and there is a beautiful neat little hinge, working easily and smoothly, and as close and firm as though it had grown there. All is the work of little more than a minute, and the jeweller's neat way of handling his tools will excite as much admiration as the neatness of his work.

The rings may next be fastened on, a still more simple and speedy operation. A piece of wire has been coiled round a piece of thick iron wire, and the coils cut through longitudinally, thus making a hundred rings at once. The lockets are ranged, a dozen or so at a time, on a slab of pumice-stone, which is to answer the purposes of the "devil." It is of circular form, and has a slightly raised rim all round it. The rings are placed round this rim, and the lockets being laid in the middle so that their ends touch them, the rings, by reason of the slight elevation on which they lie, come just in their proper places. A touch of solder is given to each, and a good blast of the blowpipe solders them all at once. Thenceforth they can be twisted about by the pliers in any direction without coming off.

Some lockets have raised ornaments on the centre, or round the border, in which sometimes stones are set. These are placed on and soldered in the same way, a number at a time. We have seen how Cellini got his *alto relievo;* this is a cheaper way, and good enough for the general market, though not calculated to make a connoisseur fall into raptures. It is in these ornaments that the jeweller finds scope for variety in design, and the plain oval trinket will grow into a Greek, a Byzantine, or an Etruscan, or sometimes into a mixture of all the styles together, in a few seconds.

The processes of making brooches, scarf-pins, bracelets, etc., are precisely similar in character to those described above. The parts are previously prepared by being raised by the stamp, "drawn through" in the manner described of certain articles in cabinet brass-foundry, made into tube, or wire, and bent into shape, the tube being previously filled with solder to prevent its flattening, and afterwards are put together with the handy pliers and the aid of the ever-accommodating "devil." One radical difference exists in the method of joining the parts of plated work, which, as we have explained, is, through every stage of its progress, a thin skin of gold on a body of baser metal. The great heat from the blow-pipe would

infallibly melt off the precious surface, so the makers are fain to be content with using a miniature tinner's soldering iron, and a solder more easily fused. The one method is called *hard* and the other *soft* soldering.

The articles are now polished, which is done by girls at a lathe. The polishing medium is grease, rottenstone, or emery, and rouge; and it is applied by a revolving brush, which finds out all the corners, and does not injure the most delicate parts. Plated work has again to be treated exceptionally, on account of its tender skin; but the metal, which was bright at the commencement, is kept bright throughout, and needs only a rub with the grease-brush to finish it. "Compo" work is of the dull copper colour left by the annealing, and has, besides, a "scale," which it is necessary to take off; some portion of the substance, therefore, is polished away. The metal being of so little value, this is of no consequence; but even if it were gold that was being so operated upon, there would be means of preventing loss. Every scrap of polisher's waste, every grain of shop dust, is religiously preserved in a gold-working establishment for future analysation. The worn-down brushes themselves, the "skins" which have been stretched beneath the boards, the very water in which the men wash their hands, all yield golden results when subjected to the refiner's art.

At different stages at or near completion, according to the nature of their construction, the articles come under the interesting manipulation of the chaser. This workman has the best claim to be called an artist of any that are employed in the manufacture. Something is left to his taste and fancy, and it is his business to put an artistic appearance on the work. For instance, work that has been stamped, however cleanly, will have a blurred roundness of detail, different from the sharpness and crispness produced by the hammer and punch. It will be to real *repoussé* what moulded glass is to cut glass. The business of the chaser, then, is to go over the design with suitable tools, and bring out its features sharply and clearly, as a statue is touched up by the hand of a master after his underlings have brought it into form by almost mechanical means. If the chaser has a real artistic feeling, and knows how to put it into his work, he will give life to the design. Again, it is his duty to enrich the surface of the work with delineated ornament, in which he has some latitude of choice. He requires for his purposes that the work shall be solid, consequently he has to fill the hollow with a composition answering to the "tenax" formerly described, but which is now generally made of a mixture of pitch, beeswax, resin, and plaster of Paris, or emery. When warm this is highly plastic, and can be easily forced into all the interstices, and even when set it is still slightly yielding. When he works with his punches on the surface, therefore, for every depression he makes there is a corresponding rise in the immediate vicinity, and by accommodating his handiwork to this property of the metal, and using a great quantity of punches of various shapes, he gets a slightly raised design. Should he require to raise any part of it still further, he melts out the composition from the under side, and embeds it face downwards, striking up the portion he desires. After he has got the design into sufficient relief, with a sharp and clear outline, he may bring it out with greater distinctness by "matting" the ground. This method, which was well known to the old artists, simply consists in striking the flat surfaces with a roughened punch, the roughness of which has been produced in one of three ways. For coarse or common work, it is sufficient to strike in the ground, flattened end of the instrument a serried rank of small holes with a very fine-pointed punch, afterwards hardening it to suit the work it has to do. A better kind of matting punch is made by *drilling* small holes as closely together as possible into the end, leaving the sharp edges; and some very fine tools of this description are made by the Genevan watchmakers for the use of chasers. The best kind of tool, however, is one the texture of which has been given by nature, and consists simply of a square rod of highly-hardened steel broken off with a sharp blow. Cellini used this kind of instrument; and probably its use would be common among jewellers of the present day, but for the extreme difficulty and rarity of getting a break of the requisite evenness. A workman may break hundreds of punches without getting one to suit him. This operation of "matting," and another which is called "veining," and which consists in indenting fine lines on and between the work, are to the raised design what shading is to a drawing. Much of the so-called chasing on common articles consists in making these linear indentations and impressing upon the work figures of scrolls, foliage, etc., in imitation of engravings. The reason why real engraving is not resorted to is sufficiently obvious. In plated work the thin covering of gold would be cut through at the slightest touch of the graver, and ruined, and for work that has to be gilt after being finished the graver would be useless, since all the effect of the clean sharp cut would be lost in the bath, and the design would look no better than chased imitation, which for such work comes cheaper. When real gold is the metal under hand, however, there is nothing like the graver for surface ornamentation. The best work, therefore, is generally engraved as well as chased.

"Lapping" is an art formerly resorted to a great deal for scarf-pins and other articles in which a solid ball of metal enters into the construction. It consists in grinding the small facets, such as those cut on a diamond to bring up its lustre, and which were cut on the gold for the same reason. It is now principally confined to gold chains, whose appearance it enhances very much. The lapper uses an iron wheel, and works not on the circumference but on the side, which is perfectly flat and true and highly polished. The grinding medium is emery, and the process has nothing in it remarkable, except the great dexterity which the practised workman shows in turning the article about between his fingers, and apparently presenting its surface by haphazard to the stone, at the same time that he is producing the most regular diamond pattern with the accuracy of a machine.

The "setter" is the last workman through whose hands the now resplendent articles pass. He is usually held to be the *crème de la crème* of the trade, as his work requires a special kind of ability which comparatively few workmen acquire. It is possible for every setter to be also a good "maker," but it is not every maker who could become a good setter. His duty is to insert the precious stones, and so to enclose them that they will remain firmly in their settings. There are two systems of setting practised—viz., Roman setting, and what is called colletting. The last appears the most simple. Little fangs or lips are left in the metal, and the gem being inserted between them, they are bent over so as to enfold it, as a rosebud is encircled by its leaves, the effect being often very beautiful. The first method consists in scooping out a small recess, or deepening a recess formerly made by the stamp, in which the stone just fits, and with very fine tools, first making a shoulder for it to rest upon, and afterwards scraping down a portion of the metal to form a lip to hold it in its place, in such a way that the manner of its detention shall be concealed. To give some idea of the extreme delicacy sometimes required in the art of gem-setting, we have but to refer to some specimens of jewellery exhibited by our tasteful neighbours in the World's Fair of 1867. One was a miniature imitation of a tulip, the streaks of colour being obtained by massing rubies, emeralds, and sapphires, and the whole of the remainder encrusted with brilliants and rose diamonds. Another was a tiny peacock, with outspread tail, each eye of the feathers being an emerald, the plumage of the breast composed also of emeralds, and the rest of the body covered with rose diamonds. Lyre-birds and humming-birds there were also, the brilliant plumage of which consisted of stones arranged according to their colours, after nature, shading off till the various tints seemed to blend into each other, and the nodding plumes sparkling with thousands of diamonds. With this glimpse of Arabian-Night magnificence we cannot do better than close our chapter on modern jewellery.

FARMING AND FARMING ECONOMY.

By Professor Wrightson, Royal Agricultural College, Cirencester.

XXI.—SWINE.

ORIGIN — SPECIES — BREEDS — MANAGEMENT — FATTENING — BACON-CURING.

The many breeds of swine found in this country have originated from two species, one of which is still found wild. Although Mr. Sidney throws doubt upon the relation of the domestic hog to the wild boar of European forests, there is great unanimity among naturalists as to his having been descended from that

widely scattered species. It must be remembered that *Sus scrofa* varies much in type with his geographical position, the German boars being very different from those found in India; and it has further been shown that the domestic breeds in these two distant regions exhibit corresponding differences with their wild prototypes. So different, indeed, are the wild boars of one part of the world from those of another, that some naturalists have classed them as specifically distinct. The many breeds of swine have recently been very carefully studied by Hermann von Nathusius, who divides all known varieties into two groups, the one descended from *Sus scrofa*, and the other from *Sus Indica*, or the domestic pig of China, Cochin China, and Siam, an animal which does not exist in a wild state. The *Sus scrofa* breeds constitute the unimproved races of Central and Northern Europe, and Britain, while the Neapolitan, Andalusian, Hungarian, and other breeds of South-eastern Europe and Turkey, have been in a great measure derived from *Sus Indica*.

We may then, without further comment, assume that *Sus scrofa* and *Sus Indica* are the types from which all domesticated breeds of swine have sprung, and that in our country the original *Sus scrofa* type has been greatly modified and improved with the more highly artificial *Indica*.

Mr. Rowlandson, writing upon the breeding and management of swine, says, "There are good grounds for supposing that the old English hog with 'flop' ears was originally the only domesticated animal of its kind throughout the kingdom," and that the improved black and white races are the result of crossing the established and original breed with Neapolitan and black and white Chinese swine, and Chinese crosses. Varieties and sub-varieties abound in every country, so numerously, indeed, as to make it difficult to trace or even distinguish them, a fact which is plainly enough indicated by the rough and ready method of classification adopted by the Royal and other Agricultural Societies, into large, small, black, and white races. White pigs are best seen in the prevalent breeds of Cumberland, Yorkshire, Lincolnshire, and Leicestershire; while black pigs are found in Berks, Hants, Dorset, Devon, Sussex, and Essex. All have been improved by alliance with *Sus Indica*, as already explained. The improved white races are divided, according to size, into large, medium, and small breeds. All may be generally spoken of as prick-eared, short-limbed, fine-boned, white-fleshed, very early in arriving at maturity, and rapid in laying on flesh. The face is generally broad, and the short nose is often almost hidden in the cheeks and overhanging forehead or crest.

The most distinctive black races are those of Berkshire and Essex, and besides these, Hants, Wilts, Dorset, and Devon each possess recognised varieties.

The Berkshire may be thus described:—The head must be short; the features wide; the snout upturned; the forehead concave; the crest overhanging the forehead; ears set rather forward, and slightly drooping over the eye; cheeks well developed; no hollow between cheeks and neck; the neck gradually thickening towards shoulders, and passing into a bold crest on the upper side towards the ears and head; shoulders wide over the top, thick through the blades, and deep, giving a good foreham; the ribs must be well "sprung" from the spine, well arched, and so formed as to give a deep side; the hips wide and level with the back; the quarters straight, "well carried out," and not drooping; the ham well filled, both inside and out, and the gammon resting on the hock, forming with the leg and foot an inverted figure 5; the belly-line close to the ground; the whole animal presenting a square, massive appearance, bounded by a gently curving line from crown to tail, and a carcase showing as little daylight under it as possible. The skin is covered with a moderate coating of hair or bristles, is black with a blush of red showing through the more sombre tint, and broken with white upon the face, feet, and the end of the tail. A general levelness of form, without patchiness and hollows, appears to be, in general language, what is aimed at by improvers of this breed. The average weight of a Berkshire bacon hog fit to kill will be at eleven months old about 20 scores, but the best quality of bacon is obtained from 9 to 14 score pigs.

The improved Essex breed was brought out by the late Lord Western and the late Mr. Fisher Hobbs. Lord Western, "while travelling in Italy (making the grand tour), observed, admired, and secured, a male and female of the breed called Neapolitan, found in its greatest purity, according to a letter addressed by him to Earl Spencer, in the beautiful peninsula between the Bay of Naples and the Bay of Salerno. From this pair Lord Western bred in and in until the breed became deteriorated. These, crossed with the then Essex, and probably the Sussex and Berkshire races, gave the material upon which Mr. Fisher Hobbs, of Boxted Lodge, worked, until at length the improved Essex was the result. These pigs are characterised by their fineness of snout, their uniform black colour, and a greater lightness of form than is seen in the case of the improved Berkshire race. The defect of the improved Essex is a certain delicacy, probably arising from their southern descent, and an excessive aptitude to fatten, which, unless carefully counteracted by exercise and diet, often diminishes the fertility of the sows, and causes difficulty in rearing the young" (Sidney).

We shall not describe any other of the black races, as they so closely resemble either the Berkshire or Essex type that no adequate idea of the minute differences existing can be given on paper. There is, however, a breed known as the Tamworth, of red colour and large size, but not likely to extend, as it is slow in fattening. It is probably closely allied to the Berkshires, as it is apt, when not finely bred, to throw pigs with more or less red colour, mixed with black. The "wattles," or skinny appendages situated upon either side and below the cheek, are very singular, and are associated with some of our unimproved races.

We do not intend to enter at length into breeding and management. Much might be written upon it, but practical knowledge and experience are so essential that we doubt the advisability of giving minute directions regarding matters which must be seen and worked upon in order to be appreciated. It is, however, a golden maxim to breed from parents which themselves inherit valuable qualities, only let us see that such qualities exhibit themselves palpably in the animals used for breeding purposes, and do not (as might be supposed) lie latent in the blood. Again, in-and-in breeding, or the breeding from animals closely related to each other, is found to be practically fatal to success in pig-breeding; this statement might be supported by many examples, and is believed by every pig-breeder.

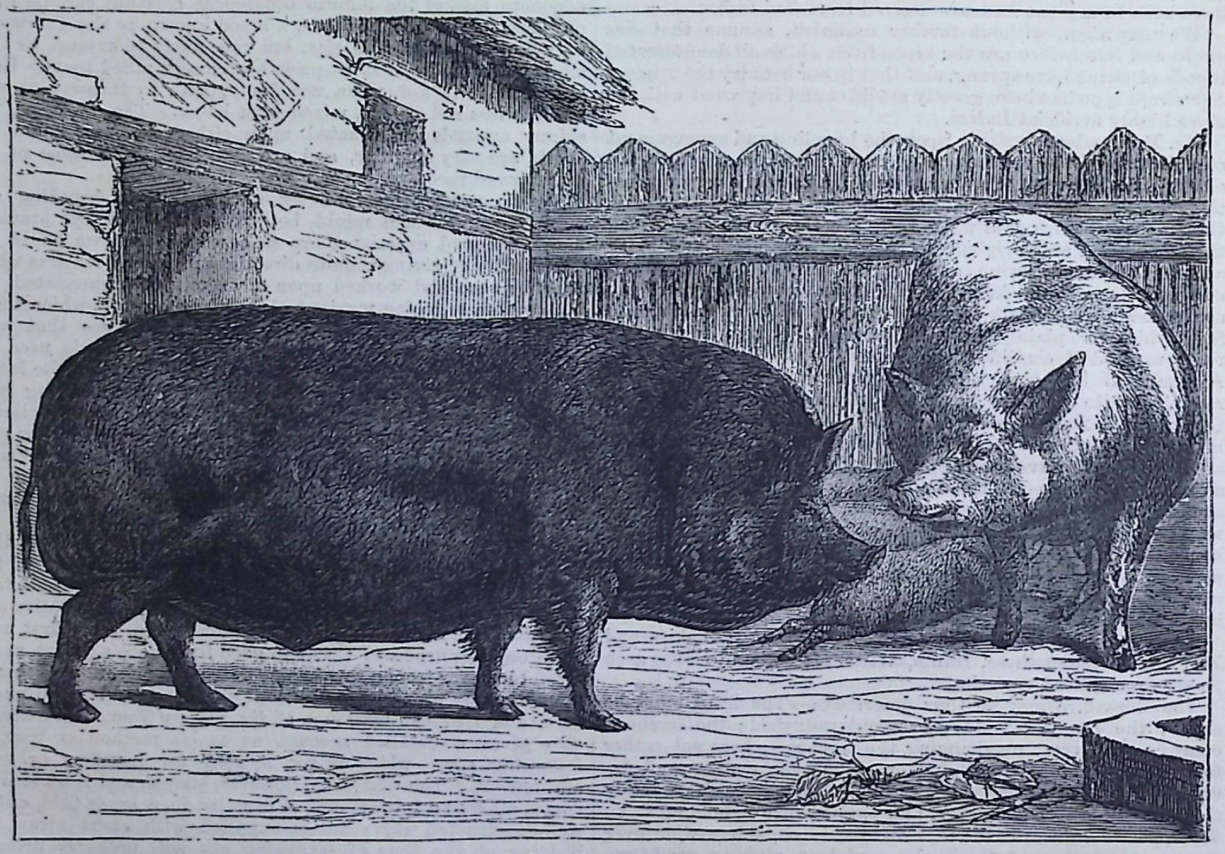
Perhaps no one has given a clearer statement upon the management of swine, or based his observations upon a longer and more successful experience, than Mr. Stearn of Suffolk. In a lecture very recently delivered, he informed his hearers that the profit or loss upon pigs depended upon the quality of the stock; that in breeding, the parents should be carefully selected; that the sow should be not less than ten to twelve months old, and the boar from eight to twelve months old, when first used for breeding purposes; that two good litters are as much as we should look for from a sow in one year; that cleanliness should be secured by properly constructed piggeries and by continuous care, and frequent *washings of the piggery floor*. Mr. Stearn also gives a detailed account as to his method of treating farrowing sows, which is too lengthy for insertion or even abridgment. The matter is, however, simple, and if a breeding sow is allowed a fair amount of exercise in a grass field, and a well-constructed sty scantily supplied with short straw for bedding, at the time of farrowing she will probably bring a healthy litter. The extreme watchfulness and numerous precautions recommended by Mr. Stearn are not practised by most pig-breeders, and it is questionable whether they are either necessary or advisable. With reference to the management of young pigs, we quote Mr. Stearn at length: "I begin to feed the young pigs at five or six days old with warm milk mixed with a little very fine sharps, and a small quantity of whole maize. For the first few weeks after being weaned, I have the boy feed them very often, but give them a very little food at a time. In the winter I feed all on warm food, but not in the summer. I give them a great variety of meal, such as wheat, maize, barley, oats, and whatever is most convenient to mix it together. I just wet it with cold water, and then scald it with boiling water and sprinkle it with salt; between meals I give them whole maize, and mangold-wurzel, or swedes cut small; and once or twice a day a little coal. I allow them plenty of clean water, and there is one thing I am very particular about, not to give them any more food than they will clear up at a time. When pigs are put to fattening it will be found very beneficial to wash them at least once a week: this is quickly done by experienced hands, and will amply repay any one for the trouble. I also like to have them very often brushed."

Every cottager understands how to fatten a pig. In a word, plenty of barley-meal given of the proper consistency, and regularly, will soon effect this in the case of well-bred swine. Why, then, should we prolong our remarks on a point which is confessedly so simple? Messrs. Lawes and Gilbert, some years ago, undertook an elaborate series of experiments upon pig-feeding, and although the results may have little effect in guiding the practice of cottagers and farmers, yet they at least confirm what has been hitherto considered as good practice, and throw light on the entire subject. The objects of these experiments, the results of which were contributed to the fourteenth volume of the Royal Agricultural Society's *Journal*, were as follow:—

1st. To find the amount of increase from a given amount of food.

2nd. The most desirable proportion of the highly nitrogenous foods to those which are not nitrogenous.

"factories," where several hundreds of swine are slaughtered in a single week, and where the curing proceeds both summer and winter with the help of ice-cooled, underground houses. The following is a very brief account of a bacon-factory, where about one hundred and fifty pigs are killed per week:—The pigs are drawn from the sty, where they have been previously awaiting their execution, by means of a chain attached to one hind foot, and are lifted by a hoist, until the nose is about eighteen inches above a grating. The chain now catches by means of a hook upon an overhead rail, which passes, with a slight downward inclination, into capacious sheds. The pig is bled, and the carcase is slid along the guideway just spoken of, until it reaches an apparatus for burning or singeing; the carcase is again pushed forward to a point where it is washed with a jet of water from a hose. Again it is passed onward into the sheds, cut down the back to facilitate cooling, and it is there rapidly



BOAR AND SOW OF THE IMPROVED ESSEX BREED.

3rd. To ascertain within what limits this proportion might be varied, so as to improve the quality of the manure, consistently with economy.

The practical facts adduced from the experiments of Messrs. Lawes and Gilbert were:—

1st. That pigs of about nine months old consume from 29 to 30 lbs. of fresh corn per head per week, and increase in weight at the rate of from 18½ to 21 lbs. per every 100 lbs. of such food consumed.

2nd. That pigs, like sheep and cattle, do not pay for their food in flesh alone, but the profit must be looked for in meat and manure.

3rd. That when pigs had a choice of diet, they preferred nitrogenous food in the earlier stage, but became more attached to the farinaceous diet as they progressed.

4th. That although bran may be useful in small quantities, it is not to be used as a basis of diet.

5th. That farinaceous foods are the best, subject, of course, to the markets.

Bacon may either be salted on a small scale at home, or in joined by other carcases, until the work of slaughter is complete. Subsequently, the back-bones, heads, and blades are removed with great dexterity. The sides, when cool, are taken to the salting cellars, and placed on the floor skin-side downwards. The sides are covered with salt, laid on and brushed in, and remain in that position three days. At the end of this period the salt is brushed off, and the sides are "stacked" for ten days, new salt being freely sprinkled over and between them. At the end of the first week, after killing, the sides are re-stacked and salted, and at the close of the second week they are again stacked and remain until the end of the third week. They are now "green bacon," and only require drying and smoking. The smoking is conducted in a high, flagged chamber, in which oak sawdust is smouldering. The sides and hams are powdered over with pea-meal, and are then hung in the smoke for three days, the whole period from slaughtering to the completion of the curing being twenty-four days. The lard is melted and run into bladders, each pig furnishing a receptacle for his own fat: fourteen pounds of lard will be yielded by a good pig.

MINING AND QUARRYING.—XXXVIII.

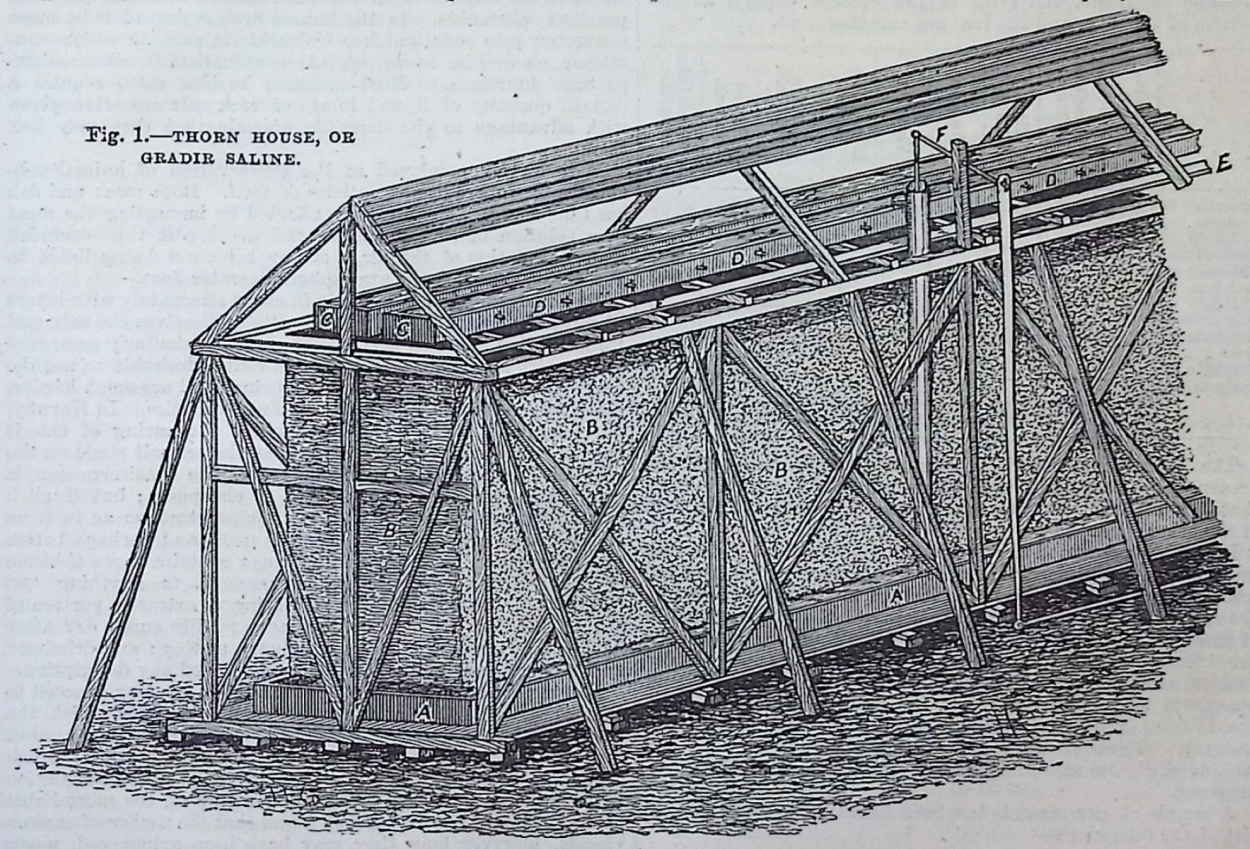
BY GEORGE GLADSTONE, F.C.S.

SALT (*continued*).

GRADIR SALINEN—CRYSTALLISATION OF SALT—ANALYSIS OF DIFFERENT KINDS—OF PAN SCRATCH AND MOTHER LIQUORS—PHYSICAL PROPERTIES OF SALT—USES—EXTENT OF TRADE.

In the first article on salt, it was mentioned that many brine-springs of the weaker class, which are very common in Germany, are utilised, though they do not contain a sufficient percentage of salt to enable the English plan to be used, and the climate will not admit of its being concentrated in salterns. The system adopted at Sulza, Münster am Stein, Dürrenberg, and other places, depends upon exposing the greatest possible surface of the water under circumstances most favourable to evaporation, whenever the state of the atmosphere is suitable.

Fig. 1.—THORN HOUSE, OR GRADIR SALINE.



For this purpose thorn houses, or, as they are called in Germany, *gradir salinen*, are erected in such a position as to be most exposed to the prevailing wind. These are gigantic erections, consisting of a skeleton of timber filled in with thorn bushes, having pumps for raising the water to the top, and a series of pipes and taps from which the water trickles down over the ends of the twigs to the cisterns below. The arrangement will be better understood by reference to the accompanying diagram, which represents the end of one of these long erections. The essential parts of the structure are distinguished by lettering; the great beams which form the framework of the whole will need no explanation. A A is a large shallow tank, extending along the whole length of the *gradir saline*, but divided into three, four or more compartments, which have no direct communication with one another. These tanks receive the drips from above. Immediately above the tanks are the thorn bushes B B, closely and evenly packed, so that their ends form a regular wall, only slightly tapering inwards as it rises. These are surmounted by a platform, upon which rest the two troughs C C, which are also divided into compartments corresponding to those of the tanks below. The brine is pumped up into these by lift-pumps, one of which is seen at F, worked by a water-wheel. The troughs have taps, D, D, inserted along their whole length at short intervals, and on both sides; and from these the brine is allowed to run gently, so that it may become broken into drops by the bushes, and trickle through them to the tank below. According to the direction of the wind at the time, the one or the other trough is supplied with the water, and, except when the wind is very high, the outside series of taps are turned on, which direct the little streams to the outer edge of the thorn wall. A platform E runs all along the top, for the man to walk upon who attends to the turning off and on of the taps. The first pump raises the water from the spring to the top of the first compartment, the second that which has collected in the first tank to the troughs of the second compartment, and so on to the end of the series, the contents of the last tank being drawn off into reservoirs to await the final operation.

On the Continent the weather is sufficiently dry and warm to enable the work to proceed during about two-thirds of the year, and it is done at a minimum of expense, as water-power is sufficient, and but little personal attention is required. During these artificial showers a great deal of water is carried off by evaporation, the brine therefore becoming stronger each time, until at last it contains about 22 or 23 per cent. of salt. In passing through the *gradir saline* another object is attained besides the concentration of the brine; for the oxide of iron, sulphate of lime, and other salts, which are less soluble than the chloride of sodium, become deposited as an incrustation upon the twigs, and the greater portion of these objectionable constituents are thus got rid of. The thorn stacks have to be replaced every few years, the length of time which they last depending very much on the quantity of these salts which the waters may contain. In some places the brine is allowed to trickle slowly over a roof laid upon a very gentle incline, and painted black; but this is only available when the weather is hot, and the sun is shining brilliantly. The concentrated brine is finally evaporated down by artificial heat in salt-pans such as that described in the last article.

Chloride of sodium crystallises in the form of a cube, and if the process of crystallisation is allowed to go on slowly, and at

a low temperature, a series of small cubes are built up one upon another until one of considerable size is the result; the increase takes place first along the edges of the primary crystal, and then the intermediate spaces get filled in, which makes it a solid. If, however, the evaporation of the brine is conducted rapidly, as in the making of fine salt, the surface of the liquor furnishes crystals of an apparently different construction, for the fresh crystals form on the upper edges of the primary one too quickly to allow of the intermediate spaces getting filled up, and so the aggregation takes the form of a hollow inverted pyramid, which floats upon the surface of the brine: it is actually the mere skeleton of the upper face of the cube.

Picked specimens of rock salt may be obtained absolutely pure; but the commercial article made from brine is never quite free from admixture with other ingredients. Of the following analyses the first four are of rock salt, the fifth is a volcanic sublimate, the sixth is the natural deposit at the bottom of the lake, and the rest are manufactured.

	Wieliczka, Poland.	Berchtesgaden, Germany.	Hall, Tyrol.	Cheshire.	Vesuvius.	Elton Lake, Russia.	Cheshire Stoved Salt.	Trapani Sea Salt.	Great Salt Lake, America.
Chloride of sodium	100·00	99·928	99·43	98·30	62·45	98·79	98·250	98·94	97·99
Chloride of potassium	—	—	—	—	37·55	0·04	—	—	—
Chloride of calcium	—	—	0·25	—	—	—	0·025	—	0·43
Chloride of magnesium	trace	0·072	0·12	0·05	—	0·13	0·075	0·16	0·24
Sulphate of lime	—	—	0·20	1·65	—	1·04	1·550	0·46	1·34
Sulphate of magnesia	—	—	—	—	—	—	—	0·44	—
	100·00	100·000	100·00	100·00	100·00	100·00	99·900	100·00	100·00

The Vesuvian salt will be seen to be remarkable for the presence of a large quantity of potassium; and it will be noticed that the sea-salt contains much more magnesium than any of the other specimens.

It will be understood from what has gone before that the salt water, whether obtained from the sea or from brine springs, contains much other mineral matter which will not be found in the salt made from these sources; some of the more insoluble of these go to form the "pan scratch" of the English salt-pans, or the incrustations on the thorn bushes of the German *gradir salinen*, while the deliquescent and non-crystallisable ingredients constitute the mother liquors of the evaporating houses, and the bitterns which drain from the stacks of sea-salt in the salterns. These are sometimes turned to advantage in the making of Epsom salts, in the glass manufacture, and for other purposes.

A sample of pan scratch has been found on analysis to consist of the following:—

Chloride of sodium	8·33
Carbonate of lime	12·50
Sulphate of lime	79·17
	100·00

but, of course, being only a refuse product, it will vary in different localities.

The same remark will likewise apply to the mother liquors. We will take as a specimen that analysed by Professor Bunsen of Heidelberg, which was obtained from the graduation works of Münster am Stein. The liquor contained 40·98 per cent. of solid matter to 59·02 of water. The solid contents were in the following proportion:—

Chloride of calcium	81·09
" magnesium	7·93
" strontium	0·70
" sodium	0·84
" potassium	4·20
Bromide of potassium	1·68
Iodide of potassium	0·02
Chloride of lithium	3·54
	100·00

together with traces of the chlorides of cæsium and rubidium; the presence of these last very rare metals is a peculiarity of this particular spring, and they are not found in other mother liquors. The very small quantity of chloride of sodium shows that in this case the common salt, which formed 79·5 per cent. of the solid constituents of the water as it rises from the spring, had been very effectually separated.

The specific gravity of rock salt is 2·13; and it possesses, in a remarkable degree, the property of allowing the passage of the heat rays, 92 per cent. being transmitted by clear rock salt, while only 24 pass through plate glass.

The uses of salt are very various. As an article of food it is not only agreeable as a condiment, but it is almost indispensable for the proper supply of the animal system; so much is this the case, that travellers in regions where salt is wanting describe it as a serious deprivation, and amongst some of the tribes of the interior of Africa it is regarded as one of the most precious substances. In the human system part of it becomes converted into soda and free hydrochloric acid, in which conditions, as well as in its original combination, it exercises important functions. Most animals, besides man, require a certain quantity of it, and lumps of rock salt are often given with advantage to the domestic animals, that they may lick them.

It is largely employed in the preservation of animal substances for future use as articles of food. Both meat and fish are thus cured. The former is effected by immersing the meat in a solution of salt or pickle, and keeping it thus excluded from the action of the air, a strong brine not being liable to absorb oxygen from the atmosphere as water does.

Fish is usually packed closely in casks alternately with layers of salt; the liquor from the fish partially dissolves the salt, and forms a brine in which this article of food is similarly preserved in a moist state; in this case it is found desirable to use the coarse-grained salt, as the crystals being solid are much harder, and dissolve more slowly than the finer varieties. In Norway, Newfoundland, and other places where the curing of fish is carried on upon a very extensive scale, the sea-salt made on the coast of Portugal, and on the shores of the Mediterranean, is principally employed on the score of cheapness; but English salt, if crystallised slowly at a low temperature, so as to form equally large crystals, is at least as good, and perhaps better for the purpose, as the sea-salt always contains more chloride of magnesium, which being hygroscopic, is anything but beneficial. The effect of the salt being to extract a portion of the liquids, the fish can be the more readily cured dry after having been exposed to this preliminary salting; and dried cod and haddock are too familiarly known to need any description.

Passing from the curing of meat and fish, we may proceed to that of timber. One of the most terrible enemies which the shipowner has to fear is the dry rot. It seems to be a kind of fungoid disease of a very spreading character, and which especially develops itself wherever deprived of a free circulation of air, so that the better constructed a ship is, the more liable is she to this affection. It was found that the timber of sunken vessels, however long they may have been submerged, never suffered in this respect; and the experiment being tried of soaking in sea-water the timber which was to be used in shipbuilding, such timber was found to be free from infection. It was found, however, very difficult to keep such vessels dry; and the constant tendency of such prepared timber to absorb moisture exercised a very injurious effect upon the iron bolts employed to fasten the timbers together. This was caused by the presence of magnesium salts in the sea-water, and a solution of rock salt is therefore now used in preference in the construction of the highest classed wooden ships. In America and other countries, where less care is exercised in their construction, it is very common for the shipowners to take a cargo of salt on board, on their first return voyage from England, just for the sake of giving the vessel a little seasoning.

In dyeing, salt is occasionally used, especially in producing scarlet, as it has the effect of heightening the colour of cochineal; but it is to the chemical manufacturer that this mineral is of the greatest value. In Article XXXIV. (p. 225), when describing the production of chlorine gas by the aid of manganese, for the making of bleaching-powder, we have spoken of the use of common salt as the source of the chlorine. The salt used in this manufacture principally comes from Cheshire.

Besides this, salt is the foundation upon which the whole alkali trade is built. It includes the manufacture of soda ash and crystals (two forms of the carbonate), caustic soda, the bicarbonate, sulphate, sulphite, and others. The processes to which the salt is subjected have already been described in "Chemistry applied to the Arts," No. VII. (Vol. I., p. 330); but it is worth while giving some idea of the quantity of chloride of sodium which is needed to supply the common element in all these compounds. The quantity consumed annually by the manufacturers in the Tyne district alone was computed in 1863 at 90,000 tons; and in the whole kingdom 254,600 tons were converted into alkali during the previous year.

The total produce of the salt mines of the United Kingdom may be set down in round numbers at 1,500,000 tons. Of this about one-half is exported to our colonies and to foreign countries, the remainder being used at home. The domestic consumption has been estimated by statisticians at twenty-two pounds per head, which, for a population of 31,465,480, according to the last census, will amount to 309,036 tons, leaving nearly 450,000 tons for the various purposes of trade, the principal of which are the manufactures of soda and bleaching-powder, and the salting of fish and provisions.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XXXIX.—PROFESSOR SIR CHARLES WHEATSTONE (*continued*).

In our last paper we brought under the notice of the reader a general sketch of the present system of telegraphy for the million, by Professor Wheatstone's new scheme; and evidence of its general popularity may be gathered from the good-natured readiness with which householders have permitted the posts to be erected on the roofs of their dwellings. To Professor Wheatstone electric telegraphy owes much. With his improved automatic instrument, 1867, properly manipulated, he can transmit six hundred distinctly visible signs or letters in a minute.

Subjoined are a few of our inventor's miscellaneous contributions to science:—

In 1836 Professor Wheatstone constructed an instrument composed of a sound-box, with a bellows attached to one end, the other the frustrum of a cone with the base outside, and keys inside the box, to the other end. By pressing the wind through the bellows, and fingering the keys with one hand, the other being applied to the end of the frustrum of the cone, the machine will utter intelligibly the words "papa," "mamma," "thumb," "plum."

In 1856, at the Royal Institution, the instantaneous duration of an electric spark, and the means ingeniously constructed by Professor Wheatstone to measure it, were illustrated by the original apparatus employed by the inventor, from which it was ascertained that the duration of a spark does not exceed the twenty-five thousandth part of a second. A cannon-ball, if illumined in its flight by a flash of lightning, would, in consequence of the momentary duration of the light, appear to be stationary; and even the wings of an insect that move ten thousand times in a second, would seem at rest.

Professor Wheatstone's new printing telegraph is so constructed that the message is sent by means of a perforated strip of paper, the holes in which, representing the letters, are made by means of a separate machine, worked by a finger-board. The advantage of this method is, that several persons can work at the finger-boards, and prepare several messages at once; and on the perforated paper being put into the telegraphing machine, it forwards the message at the rate of 500 letters per minute, being about five times faster than the former system. On its arrival at its destination, the message is again pricked off on a paper tape at the same rate, when it can be easily and rapidly read. Another advantage is, that the whole apparatus only occupies a few inches square, there being no battery required, as it is worked by magnetic electricity.

Professor Wheatstone's universal and military telegraph is especially adapted for rifle and field practice. This is a portable apparatus, also worked by magnetic power. It is extremely light, being only six inches square, and is at all times ready for immediate use, without previous preparation. The communication in the field, or between the target and the gun, is maintained in the ordinary alphabetical language by the most simple means, so that any person who can read and spell is able to work it. The communicating wire is covered with rope, and is effectually protected from abrasion or pressure when lying on the ground, though of comparatively small thickness, and when not in use it can be rolled on a drum. This telegraph is now in use in various public offices. Although small, messages are forwarded by it to a distance of twenty miles, but by increasing the size of the magnet much greater power can be obtained. In order to increase the number of messages which could be sent through the wires, in a given time, a very large use has been made of Wheatstone's automatic instruments. Fifteen circuits have been supplied with this apparatus. There are also circuits for ordinary work. The news is sent to all these places simultaneously, and at the rate of fifty to fifty-five words in a minute.

Professor Wheatstone's automatic or fast-speed telegraph consists of three parts—the perforator, the transmitter, and the receptor. The perforator consists of an iron case with three keys, which are struck down by the operator. These keys work three punches, which produce holes corresponding to dots, dashes, and spaces in the paper strip. The transmitter consists of clockwork which draws the prepared paper forward with a continuous motion by the teeth upon the periphery of a spur-wheel entering the central line of holes in the paper. The holes on the one side or the other represent the positions of positive or negative currents. There are two small vertical pins which move up and down underneath the paper strip, one under one row of holes, the other under the other row. When a hole occurs, the pin rises through it, and allows the lever to which it is fixed to oscillate far enough to make suitable contact with the battery. When, however, no hole occurs, the pin is stopped against the paper, and no contact is given. The receptor is somewhat similar to an ordinary ink-recording Morse apparatus. It is somewhat finer in the arrangement of its parts and the various moving portions, a principle upon which, no doubt, the great success of sensibility and fast working depends.

A very powerful thermo-electric battery has been constructed by Professor Wheatstone. It consists of sixty pairs of small bars, and its electro-motive force is said to be about equal to two of Daniell's cells. "On connecting the terminals of this battery, excited as Marcus's, a brilliant spark was obtained, and about half an inch of fine platinum wire, when interposed, was raised to incandescence and fused; water was decomposed, and a penny was electro-plated with silver in a few seconds; whilst an electro-magnet was made to lift upwards of a hundredweight and a half. Bright sparks were obtained from the primary and secondary terminals of a Ruhmkorff's coil connected with the battery. In fact, all the effects obtained from a small voltaic combination were reproduced with ease by this thermo-electric battery." In constructing this battery, Professor Wheatstone found confirmation of the curious fact announced by Marcus, that the power of a battery of this kind is very greatly increased by frequently re-melting the alloys of which its elements are composed. This is supposed to be due to the repeated fusion breaking down the crystalline structure of the alloys.

In Wheatstone's electro-magnetic clock, the object is to enable a simple clock to indicate exactly the same time in as many different places distant from each other as may be required. A standard clock in an observatory, for example, would thus keep in order another clock in each apartment, and that with such accuracy, that *all of them, however numerous, will beat dead seconds audibly with as great precision as the standard astronomical time-piece with which they are connected.* But, besides this, the subordinate time-pieces thus regulated require none of the mechanism for maintaining or regulating the power. They consist simply of a face, with its second, minute, and hour hands, and a train of wheels which communicate motion from the action of the second-hand to that of the hour-hand, in the same manner as an ordinary clock-train. Nor is this invention confined to observatories and large establishments. The great horologe of St. Paul's might, by a suitable network of wires, or even by the existing metallic pipe-works of the metropolis, be made to command and regulate all the other steeple-clocks in the City, and even every clock within the precincts of its metallic bounds. As railways and telegraphs extend from London nearly to the remotest cities and villages, the sensation of time may be transmitted along with the elements of language; and the great cerebellum of the metropolis may thus regulate by its power, the whole nervous system of the empire.

Thirty years from the date of his invention of the electric telegraph, Professor Wheatstone received the honour of knighthood. It must not, however, be supposed that such distinction has been earned by the above invention alone. The President of the Italian Scientific Society of Forty, in presenting to Sir Charles Wheatstone the gold medal awarded to him in place of the late Professor Faraday, said: "I cannot refrain from calling to mind that to you, Sir Charles, we owe the discovery of the method, as ingenious as it is original, for measuring the velocity of electric currents, and the duration of the spark. The applications of the principle of the rotating mirror are important and various. Not less is the invention of the stereoscope, and of the modes by which binocular vision is effected, which enables us to obtain the perception of the relief from simultaneous observation of two plane images. Also, the memoir on the measure of electric currents, and all questions which relate thereto. All physicists know how many researches have since been undertaken with your rheostat, and with the Wheatstone's bridge; and how usefully these instruments have been applied to the measurement of electric currents, of the resistance of circuits, and of electro-motive forces. To you we principally owe the practical invention and true realisation of the electric telegraph. Finally, I would call to mind your recent researches on the augmentation of the force of a magnet by the reaction which its own induced currents exert upon it."

Professor Wheatstone, D.C.L., LL.D., F.R.S., is a Corresponding Member of the Academies of Science of Paris, Brussels, Berlin, Munich, Stockholm, Turin, Milan, Rome, Washington, etc., and Chevalier of the Legion of Honour.

COTTON-SPINNING.—IV.

By J. Robertson.

THE FLY-FRAME.

The fly-frame reduces the sliver produced by the drawing-frame, and at the same time imparts a slight degree of twist for the purpose of strengthening it. Two, three, and sometimes four of these machines are used in succession. The most approved system, except where very coarse or very fine numbers are being spun, is to have three, called respectively slubbing, intermediate, and finishing frames. The mechanism of these is the same in every respect. The slubbing-frame, which receives the cans from the drawing-frame, has no racks or creels, which are required in the other two for the purpose of holding the feeding bobbins. The slub, or roving, as the cotton is called after it has been twisted into a soft cord, being reduced in size or grist at each successive frame, smaller bobbins are sufficient to hold it. This permits the spindles to be set closer, and as the frames are lighter and more easily driven, they contain a greater number of them. The following table gives twists per inch on the roving, etc., and an approximate estimate of the produce of the different frames. "Lift" means extreme traverseof the rail.

Frames.	Lift.	Diam. of Bobbin.	Revs. of Spindle per min.	Size of Roving.	Twists per inch.	Produce in 60 hours.
	in.	in.		hk.		lbs.
Slubbing	12	6	700	·5	2·71	100
,,	10	5	800	1	3·7	64
,,	10	5	900	1·5	4·6	46
Intermediate	8½	4	1000	2	5·47	33
,,	8½	4	1100	2·5	6·29	25
,,	8½	4	1200	3	7·06	20
,,	7	3½	1200	4	8·3	13
,,	7	3	1400	6	9·88	8
Finishing	7	3	1400	8	11·29	5
,,	6	2½	1600	10	12·35	4½
,,	6	2¼	1600	12	12	3½
,,	6	2¼	1600	14	12·5	2¾
,,	5	2¼	1600	16	13	2¼
,,	5	2¼	1700	18	13·5	1¾
,,	5	2¼	1700	20	14	1¼

The amount of twist given to the roving should not be more than sufficient to enable it to be wound upon and taken off the bobbin. A soft rove is best adapted for being drawn. At Fig. 1 an elevation of the fly-frame is shown. Fig. 2 shows it in section. The can A supplies the sliver, which after being taken over a guiding-rod, is passed between a series of drawing-rollers, B, fixed upon the frame C. Thence it passes down to the flyer D, which winds it upon the bobbin F. The machinery which accomplishes the various movements is very ingenious and complicated. No machine connected with this branch of manufacture has undergone greater improvements, or has been brought to greater perfection.

The rollers are similar in principle and arrangement with those of the drawing-frame. They are usually arranged in three pairs, the lower ones being fluted, and the upper ones, with the exception of the first, which is fluted also to take a better hold of the cotton, being covered with flannel and leather. The circumferences are held tightly together by means of weights hung upon the top ones. The draught is principally between the middle and front rollers. The cleaners rest upon the top rollers as in the drawing-frame. Leaving the front roller, the roving enters the tube of the flyer (Fig. 3) at A, passes out by an eye near the top of it, and down the hollow leg to B, after which it is turned once or twice round the "finger" or presser, and deposited by it upon the bobbin at C. The centrifugal presser is an exceedingly simple, and yet a most admirable invention for consolidating the rovings upon the bobbin, and thus enabling it to contain a much larger quantity than otherwise it could. It is hinged at D and D^1 upon the leg of the flyer, so that it swings with perfect freedom. Between those two points lies its greatest weight. As the spindle revolves, it acquires a considerable centrifugal force, which causes the finger D^2 to press with a corresponding force upon the successive layers which it puts upon the bobbin. The object of twining the roving round the finger, is to keep it as tight as possible when being wound up for the same purpose. The seldomer the bobbins require to be changed or "doffed" the less work is entailed upon the attendants. The flyer itself is a very nice piece of workmanship, great care being necessary to have it properly balanced, so that there may not be an undue tear and wear of the bearings of the spindles. These latter have their ends slightly tapered so as to fit into the tube of the flyer at E, until a slot in the end receives a pin, which crosses the tube for the purpose of making a thorough connection between the two. It is necessary that the flyer should be movable, so that when the bobbins are full they may be taken off and be replaced by empty ones. The bobbin has no connection with the spindle, merely running loose upon it, whilst it rests upon the top of a small wheel G (Fig. 2) which has a pin fitting into a slot in the end of it. This, as it revolves, carries the bobbin along with it. These bobbin-wheels G are driven by two horizontal shafts, attached to the lifting-rail E, E, and running along the front of the machine. The spindles are driven by similar shafts gearing into the small wheels H, H at the bottom of the frame. In consequence of the bearing or collar in the lifting rail being so far from the end of the spindle, the weight of the flyer has a tendency to throw it off the truth and waste it. To remedy this evil a long collar has been very largely introduced. This is screwed firmly to the rail, and encircles the spindle till it reaches nearly to the top of the bobbin. To prevent friction, it is hollowed out, so that it is only at its extremity that it bears upon the spindle. This necessitates the use of a larger spool which lessens the quantity of roving which can be run upon it. Otherwise it makes a very advantageous arrangement.

The speed of the spindle is fixed and uniform, and the quantity of roving delivered by the rollers is uniform when once that quantity has been adjusted to suit the amount of twist to be given it. This being so, the flyers making a fixed number of revolutions in any given time, and the front roller delivering a fixed number of units of roving, it is obvious that the bobbin must have a varying motion corresponding to its ever-increasing bulk as each new layer of roving is wound upon it. The "differential motion" accomplishes this by a curious and most ingenious combination of wheels. I shall endeavour to explain this by a reference to Fig. 4. This shows the principal machinery of the fly-frame. It is placed at the end of the frame, and is neatly inclosed with iron to prevent accidents, and to exclude dust and waste. The driving-pulley and fly-wheel are upon the main shaft A A, which passes right through the wheels C^2 and D, which are loose upon it, and have a separate motion. The wheel C is fixed upon it, and drives C^2 by means of the internal wheels C^1 and C^3. C^2 is in one piece with the wheel E, which, by its connecting wheel E^1, drives the bobbin-

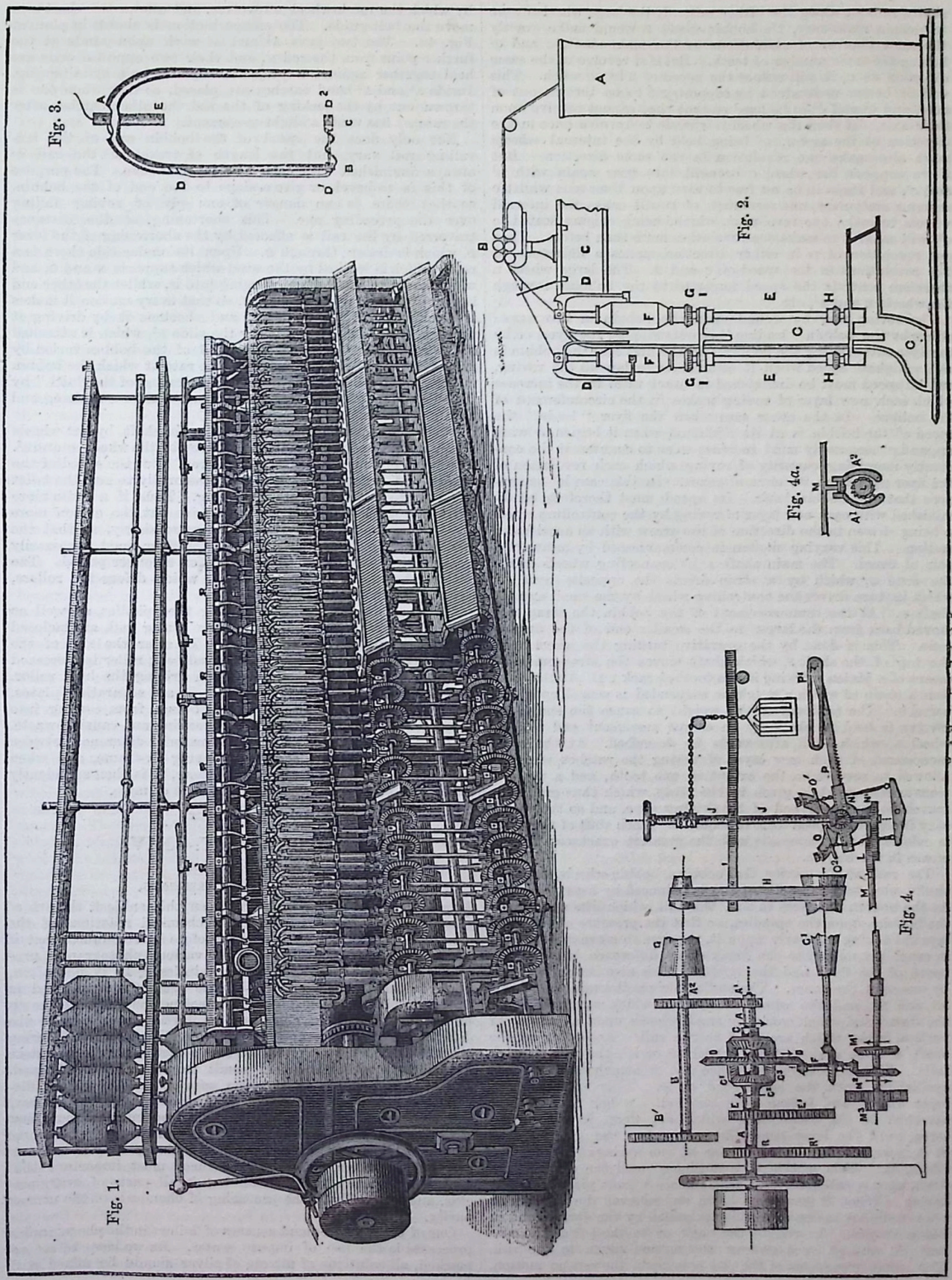


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 4a.

shafts running along the lifting rail. If the large wheel D were to remain stationary, the bobbin-wheel E would make exactly the same number of revolutions as the main shaft, C and C^2 having the same number of teeth. But if it revolve in the same direction as C, it will reduce the speed of E by so much. This will be better understood by supposing C to be thrown out of gear, and C^1 and C^3 to be fixed so that they cannot revolve upon their axis. If then the wheel D is made to revolve once in the direction of the arrow, C^2 being held by the internal wheels must also make one revolution in the same direction. But if we suppose the wheel C brought into gear again with C^1 and C^3, and these to be set free to turn upon their axis whilst C remains stationary, one revolution of D will cause the internal wheels to make one revolution, which, being communicated to C^2, will cause it to make one revolution more than before. Thus *one* revolution of D in either direction makes a difference of *two* revolutions in the speed of C and E. The large wheel D therefore controls the speed imparted to the bobbins through the wheels E and E^1, etc.

The roving may be wound upon the bobbin in two ways: either by the bobbin "leading" or outstripping the flyer, or by the flyer outstripping the bobbin. In the first case the bobbin is at its highest speed when it commences to lap up the roving, and its speed must be diminished in exact ratio to the increase which each new layer of roving makes in the circumference of the bobbin. In the other case when the flyer "leads," the speed of the bobbin is at its minimum when it begins to wind up, and consequently must increase so as to counteract the constantly increasing quantity of roving which each revolution of the flyer puts upon its circumference. In this case let us suppose that the bobbin leads. Its speed must therefore be diminished with each new layer of roving by the controlling wheel D being driven in the direction of the arrow with an accelerated motion. This varying motion is communicated by means of a pair of cones. The main shaft A by connecting wheels drives the cone G, which by a strap drives the opposite cone G^1, which in turn drives the controlling wheel by the small upright shaft F. At the commencement of the bobbin the strap H is moved back from the larger to the smaller end of the driving cone. This is done by the operative turning the wheel upon the top of the shaft J, which shaft moves the strap-guide by means of a pinion working into a toothed rack I I. At the same time a chain to which a weight is suspended is wound upon the barrel S. The tendency of this weight to cause the shaft J to revolve is held in check by an escape movement and ratchet wheel L, which shall afterwards be described. At the commencement of each new layer of roving the ratchet wheel is allowed to revolve to the extent of one tooth, and a proportionate movement is given to the strap, which thus gradually travels to the larger end of the driving cone, and so the necessary increase of speed for D is acquired. Each shift of the strap is calculated to compensate with the greatest exactness the increase in the bobbin.

The rail which carries the bobbins, bobbin-wheels, driving-shafts, etc., travels in slides, and is balanced by heavy weights. As the bobbin increases in size, this rail, which lifts and lowers the bobbins upon the spindles, so that the pressure of the flyer lays the roving regularly upon it, requires to move more slowly in exact proportion to the diminishing difference between the speed of the flyer and the bobbin. This also is accomplished by means of the cones. The shaft F drives through the wheels M^1 and M^2, and the wheel M^3 a shaft which stretches along the frame, and which works by small wheels upon a number of vertical racks which are fixed to the rail. According as the shaft F is in gear with the wheel M^1 or M^2, the rail rises or falls. This is controlled by the rod M attached at N^1 to N oscillating upon the same stud as O. O is worked by a lever rising and falling with the rail. N has two springs attached to its extremities, which act upon it with equal force, until the lever brings down or raises the opposite ends of O, when it is relieved of one of the springs by the chain lifting it. This motion of O continues until the screw comes down upon a catch, O^1 or O^2, which keeps N from yielding to the spring. When it has come down and relieved the catch, N at once oscillates to the side which is pulled by the spring, and in doing so jerks the rod to the right or to the left as the case may be, and at once reverses the motion given to the rail. This same movement of the rod acts upon the escape motion, by which the ratch-wheel L revolves, and allows the shaft J to move the belt-guide. The escape motion is shown in plan at Fig. 4*a*. The two jaws A^1 and A^2 work upon studs at the further point from the rod M, and their two opposite ends are held together against a projection upon M by a spiral spring. Inside A^1 and A^2 hand catches are placed, so that when one is thrown out by the jerking of the rod the other catches after the ratchet has made a slight movement.

Not only does the speed of the bobbin and of the travelling rail vary, but the length of travel of the rail is always diminished with each new layer of rove. The purpose of this is to bevel, or give a slope to the end of the bobbin, so that there is no danger of one ply of roving falling over the preceding one. This shortening of the distance traversed by the rail is effected by the shortening of the lever P, which is drawn through O. Upon its under side there is a ratch which is worked by the stud which supports N and O, and which having a small wheel working into it, whilst the other end is geared to the upright shaft J, so that every motion it makes is communicated to the lever, and shortens it by driving it through O, and bringing it along the slide P^1, which is attached to the rail. Thus we have the speed of the bobbin varied by means of the differential motion; the rate at which the bobbin rail travels, by the cones; and the shortening of the "lift" by the shortening of the lever, as well as the alternate rising and falling of the rail.

The rollers are driven from the main shaft by the wheels A^1, A^2, and B^1, and the spindles are driven by the wheels R and R^1. The speed of the spindle is never altered. But the speed of the rollers and bobbins are adjusted occasionally to suit the twist which is to be put upon the roving. Thus, if a little more twist is required, the rollers must give out the cotton more slowly, and the bobbins wind it up more slowly, so that the roving passing from the roller to the flyer must necessarily undergo the twisting of the spindle for a longer period. The change-wheel for this purpose is A^1, which drives the rollers, and regulation motion for bobbins.

The shafts and wheels for driving the spindles, as well as those for driving the bobbin in the lifting rail, are inclosed either with boards or sheet iron. To alter the size of the roving, the relative speed of front and back roller is increased or diminished by means of the pinion driving the back roller. Between the rollers and the flyers there are separating plates, the purpose of which is to keep the rovings from coming into contact with each other, and thus breaking and causing waste. As has already been said, there is no material difference between the slubbing, intermediate, or finishing fly-frame, and when the cotton has passed the last of these, it is then sufficiently reduced to be taken to the throstle-frame or mule.

PHOTOGRAPHY.—XIV.

By J. C. Leake.

PHOTOGRAPHIC CHEMICALS.

As we explained in our first article on this subject, the art of photography is based upon certain chemical reactions of the most delicate character; it may therefore be concluded that if these are induced, the success of the various photographic processes may be considered as certainties. It is not often, however, that anything like absolute certainty is ensured in photographic operations; but this must not be attributed to an uncertain action of the chemicals employed, but rather to the difficulty of ensuring exactly the same conditions under differing circumstances. It may be stated as a fact, that under certain conditions the same chemical result may be always obtained, and that where this is not the case it is due to the dissimilar conditions, although the difference may be so delicate as not to be readily ascertainable. As it frequently happens that a rise or fall of temperature will cause a complete failure in photographic operations, although the change may be scarcely perceptible to the operator, it becomes most important that the greatest care should be exercised in all parts of every process, and especially in the procuring of chemicals of the utmost purity.

One of the most frequent sources of failure in the photographic processes is the use of impure water. As we have before remarked, all solutions of nitrate of silver should be mixed with

water which has been distilled. Even distilled water, however, is not always to be trusted, especially when purchased in cities, as it not unfrequently happens that the droppings from steam-pipes are supplied instead of the genuine article. These are frequently tainted with oily matter from the engine; and as but little care is taken in properly cleansing the vessels in which the water is collected, it is often as bad or worse than ordinary rain-water. The best method of obtaining perfectly clean and pure water for the nitrate-of-silver bath is to distil it in a glass retort as required. Pure distilled water should leave no residue on evaporation, and should remain perfectly clear on the addition of nitrate of silver, even after exposure to strong sunlight. It should also be perfectly neutral to test-paper. Spring-water is usually tolerably free from organic matter, and may be used for the nitrate bath if distilled water cannot be procured. A small proportion of the silver is of course precipitated by the chlorides and carbonates present, but beyond a slight weakening, the solution should not be deleteriously affected. It is, however, not to be supposed that all well-water is commonly pure and free from organic matter, as we have met with some which struck a decided brown tinge after a few hours' contact with the nitrate. Rain-water is most certainly not to be depended upon, save in exceptional cases, as it is frequently contaminated with ammonia and other matters, especially in the vicinity of large towns.

Although not so important as in the case of the nitrate bath, the water employed for developing solutions should be as pure as possible. It should be remembered that (in the wet collodion process at any rate) a certain amount of silver is retained in and upon the film, and that the application of a developing solution containing a chloride or other impurity will cause a precipitation of the silver which may seriously interfere with the development. In one case within the writer's experience, the turbidity caused by impure water was so great, that only an exceedingly weak image could be obtained, while the defect was completely overcome upon the employment of distilled water. Doubtless, many failures are caused by the use of impure water in the dry processes. Perhaps in the collodio-albumen process the effect is least felt; but it will be better to employ distilled water when possible in all parts of the process until the development and intensification are completed.

Although in most cases the photographer will probably purchase his collodion ready prepared, occasion may arise for the preparation of this material at home. We therefore append one of the most approved formulæ for that purpose.

As is well known, collodion is a solution in ether and alcohol of a substance known as gun-cotton, or more properly *pyroxyline*. To the solution thus made, in order to fit it for photographic purposes, is added a certain proportion of an iodide and bromide, which combining with the nitrate of silver in the bath forms a sensitive film upon which the image is impressed in the camera. The first solution to be made is that of the plain collodion, which is prepared as follows:—Take of the finest cotton wool eight ounces, and boil it for some hours in a solution of carbonate of potassa, four ounces; water, three gallons. This process is employed to cleanse the fibre of the wool from grease and other impurities. After this the cotton must be washed to remove all trace of the alkali, and thoroughly dried. In order to convert this cotton into pyroxyline, sulphuric acid and nitric acid must be mixed in the following proportions:—Sulphuric acid, of the specific gravity 1·843, five fluid ounces. Nitric acid, specific gravity 1·437, four fluid ounces. The acids should be mixed in a porcelain vessel, and placed in a second vessel containing water, the temperature of which can be maintained at 145°. At first the temperature of the mixed acids will be higher than this, but as soon as this temperature is reached 200 grains of the dried cotton wool should be immersed in small portions by means of a glass rod. The dish must now be covered, and the cotton allowed to soak for eight minutes. After this it must be taken out of the acids and plunged into clean cold water—of course using the glass rods for this purpose. The cotton must now be most thoroughly washed, in order to remove every trace of acid. This is most important, and the washing water should be tested with litmus paper, in order to ensure the perfect removal of the acids. The cotton may be dried in the sun, or in a current of air, and it should be remembered that it is now explosive, and consequently must be carefully guarded against fire, or any higher temperature than about 120°.

In order to make this pyroxyline into plain collodion, it must be dissolved in the following mixture:—Alcohol, specific gravity ·806, 1½ pints; ether, specific gravity ·720, 2½ pints; to this add pyroxyline in small tufts, 1,000 grains. The cotton should be well moistened in the alcohol before the ether is added. The cotton will quickly dissolve, when the mixture should be set aside in a cool dark place, and decanted off for use as required.

The iodising solution is made as follows:—Dissolve in ten ounces of pure alcohol, two drachms of iodide of cadmium, eighty grains of bromide of cadmium, and forty grains of iodide of ammonium. In order to iodise the collodion for use, one ounce of this mixture must be added to each six ounces of plain collodion. It will sometimes happen that there will be a slight tendency to fogging with this collodion; if so, add a few drops—say one to each ounce—of alcoholic tincture of iodine. It need perhaps scarcely be observed that, in working with such highly inflammable materials, care must be taken to avoid accidents by fire.

Next to collodion, the most important substance used by the photographer is the nitrate of silver. This can easily be made at home, although it is questionable if it is any cheaper to make than to buy it. In order to prepare this salt, dissolve two ounces of pure metallic silver in two ounces of pure nitric acid by the aid of heat; add silver until the acids refuse to dissolve more. Evaporate the acids so as to leave the crystals dry; dissolve the mass in a small quantity of boiling distilled water, and set aside for a day to crystallise; collect the crystals, dry, and fuse. Sometimes the fused mass is again dissolved in water and re-crystallised, but this is not necessary, when the silver is to be employed for printing. For the ordinary purposes of photography, one solution of the crystals will be sufficient; but for use in the nitrate bath used for collodion plates, it is advisable to adopt a second washing. In most cases, unless special care has been taken in the preparation of the salt, a solution of nitrate of silver will be found to have an acid reaction, which in the case of the nitrate bath must be neutralised by the addition of a small quantity of carbonate of soda.

The chloride of gold employed for toning photographic prints may also be readily made at home; and as this salt as supplied in commerce is frequently impure, and does not contain the proper quantity of metallic gold, it is advisable to prepare it so as to ensure proper strength and quality. The following is a simple and effective method of preparation:—Place in a suitable vessel a half-sovereign, and pour upon it half a drachm of nitric acid, mixed with two and a half drachms of hydrochloric acid, and three drachms of water. Apply a gentle heat, but do not boil the mixture. After a few hours add a second quantity of the mixture, and if this does not effect the solution of the metal, a third may be applied. Neutralise the product thus obtained by adding carbonate of soda until all effervescence ceases. A green precipitate will form which will be carbonate of copper, and which must be allowed to separate thoroughly, a process which will occupy several hours. The solution thus obtained will be slightly alkaline, and as this is likely to promote a reduction of the gold to a metallic form, a drop or two of hydrochloric acid should be added after the removal of the precipitate. A convenient plan of keeping the chloride is to dissolve it in a known quantity of water, so as to make it, say five, grains to the ounce of solution. It can then be measured without loss. A half-sovereign contains about fifty-six grains of pure gold, which will make eighty-six grains of the chloride. Chloride of gold should be mixed in distilled water, as any trace of iron will precipitate gold in the metallic form.

Some difficulties at times occur through the varying strength of the acetic acid commonly supplied. That usually employed in photography is what is termed glacial, and should become solid at about 40°. It should contain only one atom of water. Many persons use a cheaper acid, known as "Beaufoy's." This is the "acetic acid fortiss." of the London Pharmacopœia, and contains about 30 per cent. of acid. From this it follows that rather more than three times the quantity of this acid must be employed where it is substituted for the glacial.

In concluding this subject, we would caution the photographer against the employment of impure and, as they are termed, cheap chemicals. It is but seldom that materials sufficiently pure can be obtained at the ordinary druggists, and in all cases it should be stated that they are required for photography. Under the recent Act for regulating the sale of poisons, no person can be supplied unless accompanied by a witness who knows the purchaser, and the purpose for which the poisons are required.

THE LATHE.—XVIII.

By Henry Northcott.

LATHES FOR SPECIAL PURPOSES (*continued*).

The latest novelty in the way of special lathes is an invention recently patented in this country by Giovanni Sconcia, but being a communication from Frederick Baldwin, of the United States. The invention is thus described in the "complete specification" filed at the Great Seal Patent Office:—

"The object of this invention is to manufacture chair legs, round tool handles, and other similar plain and fancy articles from wood, metal, or other hard material by means of a lathe of special construction, the feeding and shaping portion of the mechanism being made self-acting.

"The invention consists of a machine of a lathe-like form provided with a hollow mandril, through which the blank to be reduced or shaped is caused to pass by a feeding mechanism which acts automatically as the cutting or reducing progresses.

"The feeding mechanism consists of a pair of rollers, one of which is plain and the other toothed or serrated to give sufficient grip or hold of the blank under operation. The rollers are adjustable by springs, so that blanks of any size, within the diameter of the hollow mandril can be placed between them. The blank as it leaves the feed rollers is acted upon by rotating cutters which reduce the wood or metal to a circular form to prepare it for the shaping cutters. The blank then enters the hollow mandril and passes through it, when the shaping cutters are caused to act and produce hollows and projections upon it according to the shape of the pattern plate, which is upon a wheel on the side of the machine. The wheel carrying the pattern plate is fitted in a slot in the frame, so that it can be removed and others placed in its stead, according to the length of the article to be produced. The cutters are preferably of V-shape, and revolve at a high speed; they are caused to act upon the blank to give it the proper form and shape by means of a pin which works against the pattern plate. The cutters are adjustable, and follow the undulations of the pattern by means of springs; they are connected by hook-bolts to bell-cranks pivoted at the junction of the angles to ensure their proper working. Clutches are arranged to throw the working parts into and out of gear as required.

"The article as it leaves the shaping cutters is received by an automatic holder, which is also a polisher or finisher, so that the article before it finally leaves the machine is in a finished state. This mechanism consists of a set of revolving polishing wheels, which have an independent forward travel to carry the work along.

"The invention will be well understood by the accompanying drawings, in which the lathe is shown in its complete form in the several figures.

"Fig. 116 is a sectional elevation through the line 1, 2, of Fig. 117, which is itself a plan or view looking on the top; Fig. 118 is a view looking on the end at which the wood to be reduced enters; while Figs. 119, 120, 121, 122, and 123 are some of the details. The lathe is composed of standards or a frame A, supporting at its lower part a shaft B, on which the fast and loose pulleys C, D are mounted for communicating the necessary rotatory movement to the other parts by means of the pulleys E, F. The straps from these pulleys pass up between the frame A and over the discs G, H, for the purpose of rotating them. The pulley E is of larger diameter than the others on the same shaft by reason of the greater speed necessary to be given to the disc G, which carries the shaping cutters or knives. The discs G, H, are supported upon a tube or mandril *a* fixed upon or in a cross brace or bracket I, and at or about the centre of the frame A. A portion of the exterior of the tube is threaded, and has a conical head to hold the disc G in place, the opposite end of the tube being plain and of less diameter on its exterior for the reception of a conical socket *c* which holds the disc H in place. Both these discs are thus free to revolve against or upon the cones without imparting a corresponding movement to them. By this means, with the aid of the bracket I, the tube or mandril is held firmly in position to act as a guide to the wood as it is passing through. The disc H is termed the reducing disc, because it carries the knives or gouge chisels *f*, *f*, for reducing the wood, as it leaves the feeding-rollers *d*, *e*, to the proper diameter for passing through the tube *a*, supposing the wood to be of a square or other similar shape and require reducing. These cutters *f*, *f* are arranged on the outer face of the disc H, and are capable of being adjusted by loosening the screws *g*, *g*, and shifting them as desired under the plates *h*, *h*, one of which only is shown in Fig. 119. The other or shaping cutters *i*, *i*, which are carried by

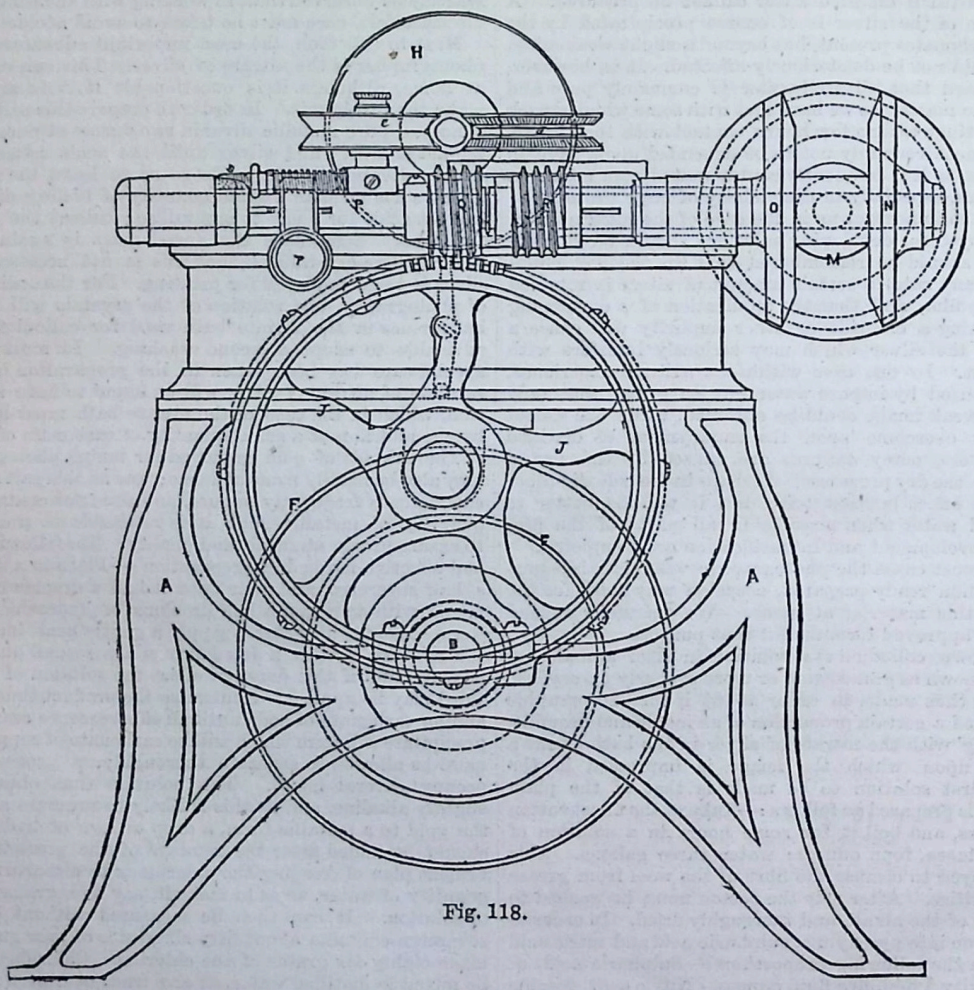


Fig. 118.

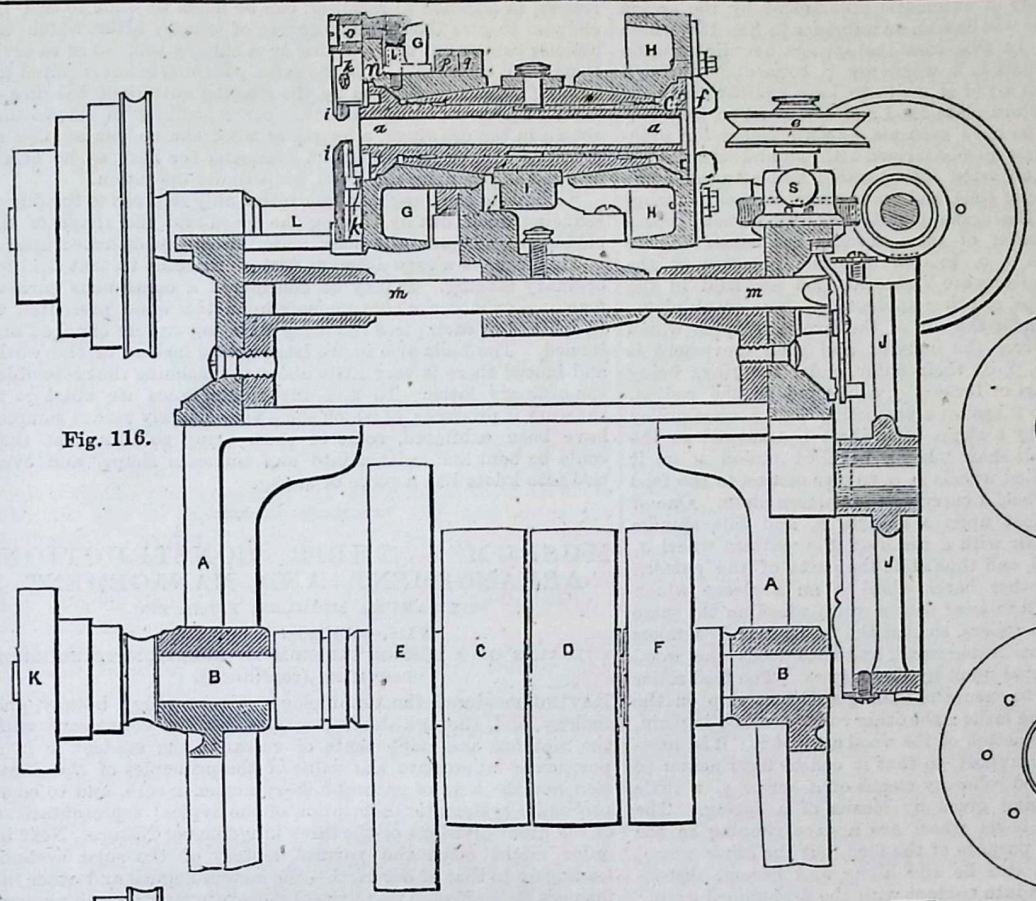


Fig. 116.

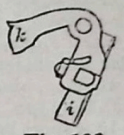


Fig. 122.

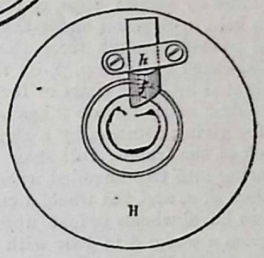


Fig. 119.

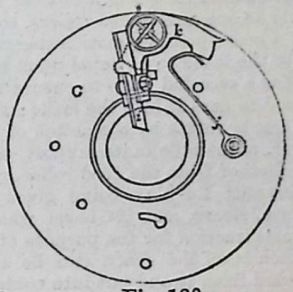


Fig. 120.

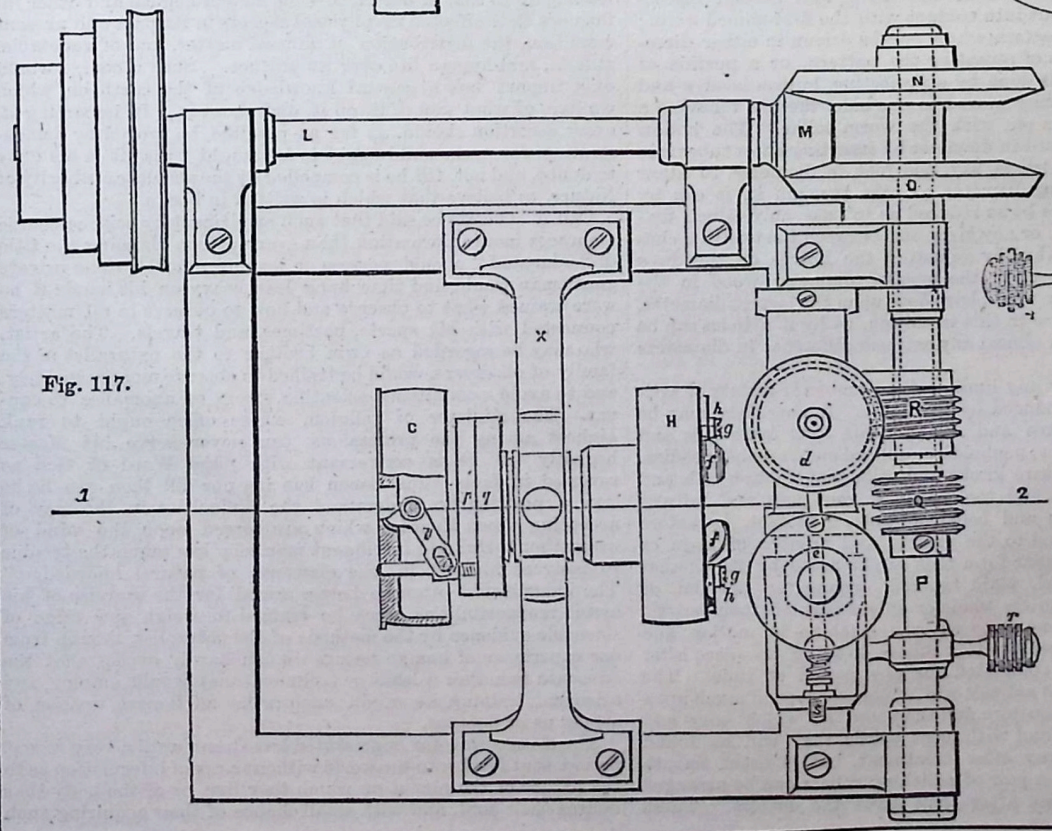


Fig. 117.

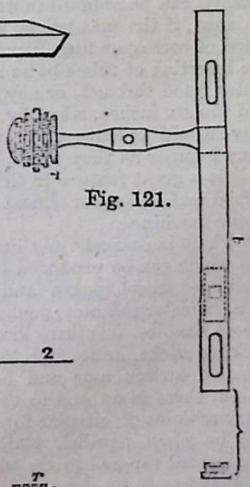


Fig. 121.

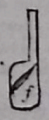


Fig. 123.

the disc G, are capable of automatic adjustment by the action of their springs *j*, *j*, as will be seen on reference to Fig. 120, which is a detached view. In this case the springs act direct upon tail-pieces of the holders *k*, *k*, which are in connection through crank-plates *l*, *l*, with a rod *m* made to bear against the edge of a wheel J or a pattern plate fixed on it. It will be found of greater convenience to have separate pattern plates for practical working, and these may be formed with slot and screw holes, so that they can be adjusted into position and screwed home tight in a short space of time, and thus prevent delays in changing the patterns. The crank plates are formed with noses *n*, *n*, and the side motion of them ensures the cutter holders moving on their pins *o*, *o*, to overcome the pressure of the springs *j*, *j*. These cutters are V-shaped, and are held in the holders by screws, clips, or other appliances. The crank plates are held in position under the rim of the disc G by pins which are passed through from the outside, and their movement is established by rings *p*, *p*, on their outer ends, the rings being actuated by other rings or forks *q*, *q*, connected to the rod *m*. The first motion shaft B has on a projecting end a cone pulley K for giving rotation by a strap to a shaft L arranged at the back of the frame; this shaft L has a bevelled pinion M on it gearing into two bevelled wheels N, O, to give motion to the feed rollers *d*, *e*, and the wheel J carrying the pattern plate. One of these bevel wheels is fast upon a spindle P, and this spindle carries a worm Q in gear with a worm on the pattern wheel J, so as to work it round, and thus shift the parts of the pattern in proper order; the other bevel wheel is on a sleeve which carries another worm R in gear with a worm wheel on the same axle as one of the feed rollers, so that the feed roller *d* partakes of a corresponding motion therewith, and thus feeds the wood into the lathe to be acted upon by the cutters. The feed roller *d* has a serrated edge to ensure obtaining sufficient grip on the wood to pass it into the lathe; the other roller *e*, which is plain, is free to rotate by the action of the wood against it: it is, however, adjustable in its support, so that it can be fixed nearer to or farther from the feed roller by means of a screw *s*, a little allowance for play being given by means of a spring. The worm, sleeve, and its bevel wheel are always running in the same direction for the purpose of the feed, but the other worm, which is on the shaft, can be slid along and become disconnected from it and put into contact with the first-named worm; by this means the pattern wheel can be driven in either direction for the purposes of repeating the pattern, or a portion of it, if desired. This is done by a projecting button head *r* and a rod *t* (Fig. 121), being moved to one side, the rod *t* having a connection through a pin with the worm collar. The hollow mandril can be reduced in diameter by inserting short tubes into it: thus, if the mandril is, say, one foot in diameter, to allow wood of corresponding diameter to pass through it, it can by the insertion of tubes be so reduced as to pass only 6-inch diameter wood through, or any given size between the twelve inches and the six inches, when by adjusting the knives on the discs they would operate upon the smaller diameter wood in the same manner as they would have done upon the largest diameter. This is a great feature in this invention, as by it articles can be turned and shaped of almost any extreme difference in diameters in one machine.

"There is scarcely any limit to the number or variety of articles which can be produced by this lathe. Among them may be mentioned wheel spokes and naves, chair legs, table legs and rails, banister columns, penholders, billiard cues, crochet needles, broom handles, furniture knobs and rails, piano action rods and walking sticks, knife and tool handles, vent pegs and railway trenails, curtain rods and bedstead poles; in fact, as before stated, there is no end to the variety and number of plain or fancy articles of circular form that can be made by it, whether they be plain parallel, plain tapered, ornamental parallel, or ornamental tapered in the whole or only a part of their length. All that has to be done is to set the machine in motion, and enter the stuff between the feed rollers, keeping up piece after piece as the work is completed for any period of time. The degree of finish to the articles will, of course, depend much upon the sharpness of the cutters and the speed at which they and the discs are driven, and with most woods they will be found fit for use without any after treatment, but if extra smooth articles are required, a pair of polishing rollers can be arranged to receive the articles after they leave the cutters. These rollers, in addition to rotating, can be made to slide to and fro endwise to give the required degree of polish; after which the articles can be cut off by a saw or a cutting tool so as to sever them from each other, or if the extra polishing is not required the cutting off can be effected by the shaping cutters of the disc G.

"In the case of a small lathe, corresponding in size to that shown in the drawings, a length of wood can be cut as fine as ordinary wire or twine without damaging the fibre, as no strain or twist is put upon the wood while under operation.

"I have in the foregoing description only referred to turning or reducing wood, but by varying the speed and the shape of the cutters, metals and other hard materials can be operated upon."

This lathe is a very different sort of machine to that used for ordinary turning. It may be considered a continuous turning machine, as it works continuously upon the wood presented to it, instead of each piece requiring to be separately chucked and turned. The tools also in the lathe rotate instead of the work, and indeed there is very little about the machine that resembles the ordinary lathe. To find any resemblance we must go to the work it produces, of which some very cleverly turned samples have been exhibited, some of them being so thin that they could be bent and twisted into any intricate shape, and even tied into knots like a piece of string.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XVIII.—SCHOOL MUSEUMS.

THE AIMS OF A SCHOOL MUSEUM IN RELATION TO SCIENCE-TEACHING (*continued*).

HAVING mastered the terminology of mineralogy, botany, and zoology, and, through demonstrations, become conversant with the methods and implements of research, the student is in a position to appreciate the value of the principles of classification and the laws of natural-history nomenclature, and to comprehend a systematic description of the typical representatives of the great divisions of the three kingdoms of Nature. Next in order might come the natural history of the solar system, leading up to that of our earth—the meteorological and other influences that affected its physical aspects in its past and present condition, the distribution of mineral matter, and of vegetable, animal, and human life over its surface. Such a course would only impart but a general knowledge of the earth on which we live, of what was in it, on it, and about it. In imparting it, every assertion should, as far as possible, be proved by demonstration, for every child ought to be taught "that it is his duty to doubt, and not, till he is compelled by the absolute authority of Nature, to believe that which is written in books."

Can it honestly be said that such an elementary science course embraces more information than every person claiming the title of "educated" should possess on leaving school? The private gentleman would find time hang less heavy on his hands if he were trained what to observe and how to observe in all matters connected with his sports, pastimes, and travels. The artist, who may be regarded as twin brother to the naturalist in the family of observers, would be trained to observe more accurately, and to avoid committing scientific errors or anomalies to canvas. The minister of religion, whose office ought to rank highest among the professions, can never serve his Master honestly till he is conversant with "the Word of God as revealed in facts" (as Bacon has it), nor till then can he be "in a position to understand the difficulties in the way of accepting those theories which are forced upon the mind of every thoughtful and intelligent man who has taken the trouble to instruct himself in the elements of natural knowledge." The judge would often be better armed for the exercise of his awful responsibilities were he trained to weigh the value of scientific evidence by the methods of the naturalist, though from our experience of human nature we can hardly expect that the advocate (whether a legal or technical one) would employ any scientific training he might acquire as an honest weapon of attack or of defence.

The classes thus far enumerated have been, until a very recent period, sent forth into the world without a rag of information as to the nature of the planet on which they live, or of the body that houses their soul, and with small chance of their acquiring such

kind of information during their professional training at our universities. Unless some inborn instinct forces them to seek such knowledge for themselves, how much of modern literature must remain but as a dead language, how much of modern intellectual society be but as a charmed circle, wrapped in impenetrable mystery! The medical, army, or navy man, the architect, the engineer, the mine-master, the manufacturer, the agriculturist, and the commercialist is either taught at a special school, or he "picks up," in the course of business, such portions as meet his needs of the grammar of science, of which he has not been taught the alphabet. Is it to be wondered at that so much professional and commercial practice is still governed by "the rule of thumb?" Well might Professor Huxley have entered the following protest:—"What is it but the preposterous condition of ordinary school education which prevents a young man of seventeen, destined for the practice of medicine, being fully prepared for the study of Nature, and coming to the medical school equipped with that preliminary knowledge of the principles of physics, chemistry, and of biology upon which he has now to waste one of the precious years, every moment of which ought to be given to those studies which bear directly upon the knowledge of his profession." He might have made a similar protest against the schooling of those students who are sent to the School of Mines, unfledged as to the rudimentary features of science, for I well remember, during his second year at Jermyn Street, some of the youths had never heard of insect metamorphosis, so he had good cause for regret that valuable time should be wasted in his having to dwell on the veriest rudiments of biology.

At what period in life should science-teaching commence? Professor Henslow has proved that an expert teacher may begin with advantage on the youngest even of a village school class, and he gave as his experience that children show great avidity to learn even such subjects as practical botany. At Rugby, even when dealing with boys of fourteen, their experience was not of so satisfactory a character. "For the first half-year of 1865 natural science was taught to every boy in the middle and lower school, the sixth form and upper school being allowed to choose between German and natural science. After six months' experience, however, it was decided to drop the subject in the lower school, the boys appearing hardly equal to the work." But much depends upon what is attempted and the manner of teaching, for a master who may be very successful in dealing with youths, might fail utterly with mere boys, and it requires special tact for a teacher to bring his ideas and modes of expression down to the level of a child's comprehension and create an interest for what many would regard as dry subjects, which, nevertheless, have been made subject-material for amusement in the Kinder Garten. If science is to be taught in our schools, there is no reason why a beginning should not be made in the first spelling-books, and statements of facts be made to replace the silly sentences to be found in existing primers, without making them of the Gradgrind class. It is now the almost universal custom to divide our public schools into three divisions, the *lower*, *middle*, and *upper*, and to adopt the *bifurcating system* after the middle school has been passed, that is to say, to give a youth the opportunity of selecting his future course of study, either in the *classical and mathematical*, or in the *modern* division, as his future may be destined for a university education, or medical, military, naval, mechanical, or commercial training, and in some schools this system is still further elaborated; such a system is founded on a common-sense view of the difficulties presented by the requirements of modern education, and is well adapted to meet the aims of science-teaching, if supplemented by what might be called the "practical science" division. Thus, supposing a science lecturer and an assistant under the title of examiner in science, were appointed both in the lower and middle schools, such an elementary course as I have previously indicated could be thoroughly mastered by any boy who had passed both divisions. The superintending masters should be appointed for their qualifications as naturalists, while the masters in the upper school should be appointed for their qualifications in chemistry, physics, and applied science; as the aim of the upper school course should be to impart general instruction of an advanced character in chemistry, physics, etc., and special instruction in the "practical science" division, according to the requirements the professional or commercial future of a boy might demand, for which purpose the boys should be sorted into "sets," such as medical, mechanical, agricultural, manufacturing, commercial, etc., and the nature of the observing, analytical, and operative processes selected by the masters, should be suited to each set. All belonging to the upper school should undergo an elementary course of observatory and meteorological practice, and also exercise as "field naturalists," with a view of adding to the "local collections" of the school museum, in addition to practice as collectors. Such a practical course would provide ample exercise in the processes of *deduction* and *verification*. The members of the upper school should be encouraged by the co-operation of all the masters to establish societies and publish annual reports, as these afford good practice in composition, in speaking and experimenting in public, which tend to give youths a calm and collected bearing in society.

In the lower school a lecture, illustrated experimentally, should be given on alternate afternoons, on the principles and terminology of natural history, in a lecture theatre large enough to hold the entire division. All specimens, diagrams, etc., should be left, and on the following morning the examiner should meet the same class, and receive from each boy the best-written report he could give, illustrated with diagrams of the previous day's lecture, especially dwelling on terms and their derivations. He should then conduct a *vivâ voce* examination on the previous day's work, and ascertain that the subject matter was fairly mastered. After the class was dismissed both lecturer and examiner would be free to replace all apparatus, diagrams, etc., in the museum, and prepare for the next day's lecture. For those boys who were in doubt on any point discussed, a question-box should be provided, into which they could drop written queries. On a third day in the week the lecturer should give a summary of the two previous lectures, and repeat or enlarge upon those points on which questions had been raised, thus making sure that the week's work had been thoroughly comprehended. The reports of the week's lectures should be returned to each boy, duly marked according to their value. On the other alternate afternoons and mornings in the week the lecturer and examiner of the middle school should, in a similar manner, treat the subject of descriptive natural history, so that the week's work in the lower and middle schools would stand thus:—

Days of Week	M.	T.	W.	Th.	F.	S.	M.
Afternoon Lecture . .	M_1	L_1	M_2	L_2	M_3	Holiday ‡	M_1
Morning Examination * .	—	M_1	L_1	M_2	L_2		M_3
Morning Summary † . .	—	—	—	—	L*		M*

L indicates Lower, M Middle School.

The lectures pertaining to the upper school and practical science division might be given in the theatre daily at noon, between the morning examination and the afternoon lecture pertaining to the lower and middle schools, thus by judicious arrangements and construction one large theatre might serve all the requirements of a very large school, including the "want" of a large hall for occasional meetings, prize distributions, etc., demanded by the head master of the City Middle Class School, previously noticed. All practical work, such as preparing chemical and physical experiments, etc., for the lectures (which should be participated in by all the practical science sets), qualitative and quantitative analysis, exercises in the use of physical instruments and investigations, practical natural history, engineering practice, should be carried on in the chemical, physical, and biological laboratories and workshops. Such a scientific curriculum at our great schools could be carried out with advantage, so as to free our medical, military, and other special schools from much matter of a general character introductory to many departments of professional and commercial life, that now has to be given to small classes which do not, even with high fees, pay the teacher sufficiently well to allow of apparatus, specimens, and illustrations being provided on a proper scale. When the time has arrived for science-teaching in our great schools being organised on some such scheme as I have indicated, then a student, after he had gone through the lower and middle schools, should be in a position to pass the matriculation examination of the

* From 9 to 10. † From 10 to 11.
‡ It is becoming a general and judicious custom to give a whole holiday on Saturday, instead of two *half*-holidays in the week.

University of London, etc.; after he had gone through the upper school and practical science division, the examinations for the Bachelorship of Science; after he had gone through the medical school, military, naval, or technical college, etc., the Examinations for the Doctorship of Science, and attain the diplema to practise in any special calling that demands practical scientific knowledge. I believe it would be to the advantage of sound scientific teaching in the United Kingdom if a *few* schools, suited to the needs of the working, the middle, and the wealthy classes, well placed as to the active centres of professional and commercial industry, were *perfectly* organised, equipped, and officered; for such requirements demand large revenues that can only be acquired by numbers or endowments, and can never be attained to if such work is scattered among a number of schools possessed of moderate incomes, or till Government aids in the reduction of the cost of text-books, apparatus, specimens, etc., by the adoption of a definite graduated system of science teaching similar to that adopted by Continental Governments.

The aim of a school museum should be to present an open Index to Nature—ever ready for every boy to refer to at any moment he is free from the class-room and in the mood to refresh his memory on any subject he has been previously taught, or extend his knowledge on any matter he takes special interest in. Such an *index* should present to the eye, by aid of well-displayed specimens (most carefully selected for their characteristic or typical nature), models, drawings, magic lantern slides, labels, and wall decorations, *an illustrated Epitome of Nature*, giving the main headings of the constituent chapters of that great work which spreads its pages over the entire Universe; and, further, indicating the subject-matter of the subsidiary paragraphs when detailed information is sought for, more especially that bearing on the local collections. Such an index to the book of Nature (the subject-matter of which is expounded in the school lectures) should be displayed in open cases (every care being taken to indicate the inter-relation of the several volumes in which the whole vast work is bound), in a well-lighted, warm, and comfortable room, so as to be conducive to quiet study. To a description of the details of construction, arrangement, and management, I proceed in my next paper.

HOROLOGY.—III.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

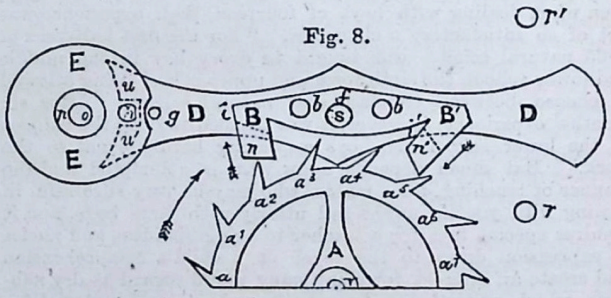
THE LEVER ESCAPEMENT.

We now proceed to describe the Lever Escapement, which, although it is more complicated in all its various modifications than any other escapements upon which we have to treat, is less costly to produce than either the chronometer or duplex, and being less delicate than both these and the horizontal, is not so susceptible to damage by careless treatment, or unskilled watchmakers, and hence less expensive in general. Our limited space will not permit us to describe every variation of this kind of escapement, we shall therefore chiefly confine ourselves to its simplest form, a description of its parts, and action of its mechanism, with a few outlines of the principal modifications and their practical results.

Fig. 8 represents the plane of one of this kind. A is the escape-wheel, mostly made of brass, carrying on its rim fifteen teeth, of which eight are here delineated—viz., a, a^1, a^2, etc. etc. It has a circular hole at v, through which passes a brass collar or collet, which unites both the arbor of the pinion and the wheel in a firm mass, this pinion being in communication or pitched to the seconds-wheel, as described in our last. B B′ is a piece of steel of the form indicated, and called the pallets (plural by reason of the individuality of its sections n and n^1). At n and n^1 there are two notches cut parallel to the plane, leaving sufficient substance to ensure stability. These notches, cut to the depth indicated by the dotted lines, are filled in with jewels of garnet or ruby, their vertical faces being slightly rounded. At s is a circular hole, through which an axle or staff, called the pallet-staff, is driven tight at right angles to the plane. D D is a piece of steel, mostly, in London-made escapements, of the form indicated, and called the lever. It is fixed firm to the pallets by the staff passing through s, and two brass pins passing through both lever and pallets at b b. At u u^1 it has a rectangular notch cut, the depth of which will be defined at a later period. g is a brass pin, put in a hole in the lever at right angles to its plane. E E is a steel disc called the roller, having a small recess or crescent cut into it opposite the pin g. At h a hole, generally circular, is drilled through this roller, and a jewelled pin, called the ruby pin, inserted at right angles to the plane of the roller. o is a circular hole, through which the axle of the balance or balance-staff is driven tight, so as to form a rigid mass; p is a projecting part of the roller, forming a steel collar or collet to give additional stability; r r^1 are brass pins inserted into one of the plates of the watch, and vertical to its plane.

The relative positions in plane will be defined later; the vertical positions or elevations are as follow:—The escape-wheel A is in plane or level with the jewels or pallet stones inserted into the pallets B B′ at n and n^1; and the lever D D is placed either above or below the pallets, according to the general build of the watch demands. The relative position of escape-wheel, pallets, and lever is determined by the shoulders of the pivots of the escapement and pallet-staff between the plates, when they are not jewelled or have single jewel-holes; and by the ends of the pivots, when they have jewel-holes and covers, that is, holes for the pivots to run through, and flat stones, covering the ones with holes, against which the pivots rest, and between which (that is, the cover to one pivot and the cover to the other) they have slight play or end-shake. The roller E E is above the lever D D, sufficient room being left between them, that no contact of their respective planes can take place. This position of the roller is again determined by the ends of the balance-staff pivots, as described above. The jewel-holes are small discs of garnet, sapphire, or ruby, set in brass collars called settings, which are in their turn let in, and screwed into the plates of frame watches for the placing of

Fig. 8.



escape-wheel and pallets, or in three-quarter plates into the plate on one side, and into a piece of brass overlapping the wheel and pallet on the other, which piece of brass is called the escape-cock. Again, the balance-staff jewelling of a frame watch (that is, a watch that has the balance above the plates) is set into two such pieces of brass, one called the potance and the other the balance-cock, both being screwed to the top plate. In the three-quarter plate or cock watches (that is, a watch with the side of the top plate cut out to give room to the balance with which it is level, or a watch having a separate cock for each wheel) the balance-staff jewelling is let into the plate, or a flat piece of brass underneath the plate on one side, and into a cock on the other. The jewel-pin, called ruby-pin, h in the roller E E, projects downward, the end reaching below the lever D D. The brass pin g in the lever is long enough to extend to the top part of the roller. The pins r r' called banking pins, fixed into the top plate of a frame watch, and into the bottom or pillar plate in a three-quarter plate watch, are extended above or below the lever.

The mechanism and its action are as follow:—The direction of the escape-wheel is indicated by the arrow, and by reason of this motion, tooth a^2 is in contact with the pallet-face n, called the driving plane, such being the position of the escapement at the moment that power is transmitted to the escape-wheel, or when the watch is wound up. The face of this pallet presents a moving incline or wedge to the direction of the tooth a^2, the pallets B B being movable about their centre or pivots of pallet staff s. Hence, a rotary motion is communicated to both pallets and lever, taking the direction indicated by the arrow. Tooth a^2 will move down this incline or driving plane n, until it

passes off into vacancy. The contact which has thus given a receding motion to section n of pallets, has also moved section n^1 about the centre s, and in the direction of the escape-wheel. When, therefore, face n ceases contact with tooth a^2, the inner surface i' of pallet section n^1 has passed within the periphery of the escape-wheel, and the escape-wheel being now disengaged of pallet section n, moves freely forward until tooth a^4 is brought in contact with i^1 of pallet n^1. This movement is called "trop," and is generally at an angular measure of one to two degrees.

We have now to conceive the wheel moved forward, and tooth a^4 in contact with i' pallet section n', in order to trace the relation between them. This inner face i' presents also a movable inclined plane or wedge to the direction of the wheel, and is so constructed that the force of the wheel draws the pallet n' towards it as indicated by the arrow, until its motion is stopped by contact of lever D and banking-pin r. The inclined face i' is called the inner locking-plane, and the vertex of the angle formed by the locking and driving-plane n', the locking-edge, and the last described position of the pallet, by reason of the contact of the tooth a^4, is called the inner locking.

We have, therefore, had a continuous rotary motion in both the escape-wheel and pallet, but under different conditions, the velocity of the escape-wheel, and the force communicated by it to the pallets, depending on the angles formed by both driving and locking-planes with the direction of the wheel.

To make these relative conditions as clear as possible, let us suppose the locking plane i' to be replaced by an arc concentric with centre s, and it will then be seen that no motion can be communicated from the wheel to the pallet. Giving now the locking plane an outward and receding inclination from this imaginary arc, it follows that, as the wheel could not have transmitted any force to the pallet, and so remained stationary while in contact with this arc, now by contact under these new conditions, a rotary motion of the pallet produces also a corresponding one in the escape-wheel, and *vice versâ*, and the force communicated by the wheel to the pallet, or the force with which the pallet is drawn towards the wheel, and the lever D held up to the banking pin r, is proportioned to the angle of the locking-plane with the pallet-radius to locking-edge, or what is the same thing, its inclination with the direction of the centrifugal force of the wheel. The faces of the escape-wheel teeth are inclined, so that contact at the point takes place only, in order to prevent contact and cohesion of two surfaces.

We will now trace the result of the pallet movement up to this point between the lever and the roller E E.

The ruby pin h passes through the notch $u\ u'$ of the lever, and in such a manner that it is perfectly free, neither sticking tight nor shaking from side to side. The pallets and lever being a rigid mass, the force transmitted to the pallets by contact of tooth a^2 and driving-plane n, is imparted by the lever to the roller through contact of the side u of lever-notch $u\ u'$ and ruby pin h, and assuming that this force is greater than the resistance of the pendulum-spring, the lever moves in the direction indicated by the pallets, and so imparts rotary motion to the roller E E. The ruby pin remains in contact with the notch of the lever, till the motion of the latter is arrested by pin r. The contact of lever and roller is conditional to two intersecting arcs described between their respective centres, the radius of one being expressed by the distance of lever-centre s to end of lever-notch $u\ u'$, and that of the other by the roller radius to centre of ruby pin h. The length of lever arc being determined by the banking-pins $r\ r'$, the position of the end of the lever-notch must be at the same distance from the line of the two centres, as the point of intersection of two arcs, to give free exit to ruby pin h at the moment when the lever is arrested by banking-pin r.

We will now consider that the escapement was in the position our diagram illustrates at the instant the winding took place, after which, impulse being communicated by the rotary motion of tooth a^2 on driving-plane n to the roller, through contact of ruby-pin h and lever-notch, the balance received sufficient momentum to continue its vibration after it makes its exit out of the lever notch. During this part of its vibration it is totally detached from the rest of the escapement, hence its title, "detached escapement." The momentum thus imparted to the balance being expended as before explained, a new and return motion takes place, the result of which on the escapement we have next to trace. It will be remembered that the lever is held in its position of rest against the pin r by the contact of tooth a^4 and locking-plane i', and therefore the lever-notch is where the pin h left it at the point of its exit; and hence the same conditions that permitted its exit will also allow its entry.

Considering that at the moment of entry into the lever-notch the last is in rest and the roller in motion, we have the changed conditions of the roller, which is simultaneous in its motion to the balance, giving movement to the lever; the conditions under which such takes place we have next to point out.

As the lever is held to the banking-pin, r, by the rotary force of tooth a^4 in contact with locking-plane i', it follows that the force giving motion to the lever, D D, must be greater than the resistance, which force is lodged in the balance momentum and the pendulum-spring. We will take the position of the point of tooth a^4 at an angular measure of 2° 30′ from the locking-edge, or rather say the position of the locking-edge within the periphery of the escape-wheel is equal to 2° 30′, measured from its own centre. As we have seen that the result of the locking of the pallets by the escape-wheel has been a forward motion of the latter, and to the amount of the difference of the deviation of the locking-plane i' from an arc described from the locking-edge, and with its radius to the angular point stated above, so must now to the same amount the escape-wheel be brought back again, which return motion of the escape-wheel is called a recoil; from which we gather that the greater or firmer the locking, the greater the resistance to the balance when the unlock- or relieving takes place, which being at the expense of the balance momentum, is the evil we have referred to in our last article. This balance resistance by unlocking is equal to the quotient of the product of pallet-radius of contact, cosine of the angle formed by i' with pallet-radius, and centrifugal force of wheel, divided by the product of balance momentum, pendulum-spring force, and lever and roller radii ratio.

We see from this definition that the roller-pin has to push the lever before it, until the locking-edge of pallet n' is in the peripheryof the escape-wheel, when a total change of conditions takes place again.

The locking-edge being the vertex or climax of two inclined planes, i' and n', the moment this is reached and passed, that is, the moment this edge has passed outside the periphery of the wheel, tooth a^4, by its latent rotary force, passes on to the driving-plane n', when the attractive effect is momentarily changed into a repelling one, by which the resistance to the balance and contact of ruby pin h and side u' of lever-notch $u\ u'$ ceases, and the contact of the side u and opposite part of pin h commences, and impulse is again imparted by the contact of tooth a^4 on the driving-plane n', thus giving motion to the lever; the angular motion of this impulse being again proportioned to the inclination of n' with the direction of the centrifugal force of the wheel which is the tangent to the radius of contact.

When tooth a^4 has arrived at the end of the driving-plane n', called the outer delivery edge, and their contact again ceases, by the simultaneous motion of pallet n, the edge of face i of pallet n has in its turn passed within the periphery of the escape-wheel, and being inclined at the same ratio as locking-plane i, locking again takes place. The pallet n, by contact of tooth a' and the outer locking-plane i, is driven towards the wheel, until its motion is arrested by banking-pin r'; and the ruby pin h, making its exit out of the notch $u\ u'$, allows the balance to complete its vibration, after which, with its return vibration a repetition of the action just described occurs, as long as the escape-wheel is rotated by the preceding wheel, and so on.

We will now take the relative position in plane of wheel and pallets, lever and roller, and the former two to the latter two, into consideration; and for this reason go back again to the position of the escapement in our diagram. Following up the passage of tooth a^2 on driving-plane n, the moment arrives when the escape-wheel passes off. As we have seen that according to the position of the point of tooth a^4, being on locking-plane i' or driving-plane n', so in the first case the pallet is attracted and in the second repelled; the position of the locking-edge of pallet n', at the instant the contact of tooth a^2 and driving-plane n ceases, determines either one or the other. If it be within the periphery of the escape-wheel, locking takes place as described; if without, so will, according to its position outside the periphery, tooth a^4 pass on to the driving-plane n',

or albuminoids) are used for the purpose of repairing the animal mechanism, and developing *energy*, or motive power. On the other hand, Mayer, Voit, Fick, and Wislicenus, Frankland, E. Smith, Haughton, and other eminent authorities, assert that not only the heat of the body, but also its energy, are chiefly maintained by the fatty portion of food. They assert that during activity the muscles increase in weight instead of diminishing, whilst under prolonged exertion the fatty tissue rapidly diminishes in quantity. The results of some interesting experiments recorded by Dr. Austin Flint of New York, in 1870, in a work entitled "The Physiological Effects of Severe and Protracted Muscular Exercise," are in favour of Liebig's views, whilst Dr. Parke's investigations appear to show that the truth lies, as is so often the case, between the theory of Liebig and that opposed to it.

The question whether the nitrogenous or the non-nitrogenous food materials are the most important agents employed in sustaining the heat and motions of the body is of practical importance to the stock-feeder. When animals are fed upon grass, hay, and roots, these articles, no doubt, supply, in properly balanced proportions, all the substances required for the nourishment of the body; but when "artificial foods" are purchased the question arises, Which are the most economical and suitable? those which are rich in fat, or those which contain abundance of nitrogen? Some years ago the value of a food substance was measured by the amount of nitrogen which it contained; and the oil cakes were believed to owe their highly nutritious properties to their large per-centage of albuminates. There is, however, but little doubt that it is the fat which exists so abundantly in linseed and rape cake that chiefly renders those foods so valuable. In the case of oxen, sheep, and pigs, the most valuable foods are those richest in palatable fats and oils; whilst for horses and other working animals a diet somewhat less oleaginous is more economical. In the case of young animals, a diet rich in albuminous substances is necessary, for whilst starch, sugar, and fat may fully maintain the heat and energy of the body, its muscles can only be repaired by the albuminates.

We append in a tabular form at the end of this paper, the results of the elaborate experiments of Messrs. Lawes and Gilbert, showing the composition of the three most important animals of the farm which are used as food for man.

On an average the pig consumes daily from 26 to 30 pounds weight of food for every 100 pounds of its own weight, the sheep about 15 pounds and the ox from 12 to 13 pounds. The pig stores up in "permanent increase" (that is, incorporates permanently with its body) about 20 per cent. of the weight of its food, excluding the water which the latter includes. Sheep retain 12 per cent. of the weight of their (dry) food. The relative increase of the nitrogenous, fatty, and mineral constituents of the carcases of oxen, sheep, and pigs is shown in the table:—

Cases	Estimated per cent. in Increase whilst Fattening.			
	Mineral matter (ash).	Nitrogenous matter (dry).	Fat (dry).	Total dry substance.
Average of 98 oxen .	1·47	7·69	66·2	75·4
Average of 348 sheep	1·80	7·13	70·4	79·53
Average of 80 pigs .	0·44	6·44	71·5	78·40

A very large proportion of the food consumed by animals is expended in keeping their bodies warm. The colder the atmosphere is the greater is the quantity of food consumed in maintaining the temperature of the blood up to 100°. In the case of man, clothes are a partial substitute for food. The naked body parts readily with its heat, which radiates from the skin into the air. Clothes are a bad conductor of heat—*i.e.*, heat does not readily pass through them; therefore, when the body is clothed, a wasteful expenditure of heat is prevented, and the necessity for heat-giving food is diminished. The hair, fur, and feathers of animals subserve, amongst other purposes, that of preventing too rapid an escape of heat from the body. Notwithstanding the covering with which nature has furnished the bodies of the lower animals, they often die from exposure to intense cold. The farmer should not allow his stock to be exposed to much cold during the winter and early spring, and he should carefully protect them from the influence of cold winds. Young animals are less able to resist cold than adults, and therefore young stock should not be allowed to remain in the fields during the whole winter, as is sometimes the case in various parts of the British Islands.

Oxen, when fed in stalls, fatten more rapidly and consume less food if kept in a temperature of from 75° to 90° Fahr. It is, however, difficult to keep a feeding-house highly heated and well ventilated at the same time, and it is better to have a cool and well-aired stall than a hot and badly ventilated one.

SUMMARY OF THE COMPOSITION OF THE TEN ANIMALS, SHOWING THE PER-CENTAGES OF MINERAL MATTER, DRY NITROGENOUS COMPOUNDS, FAT, TOTAL DRY SUBSTANCE, AND WATER.

1st. In Fresh Carcase. 2nd. In Fresh Offal (equal Sum of Parts, excluding Contents of Stomachs and Intestines). 3rd. In Entire Animal (Fasted Live-weight, including therefore the weight of Contents of Stomachs and Intestines).

Description of Animal.	Per cent. in Carcase.					Per cent. in Offal.					Per cent. in Entire Animal.					
	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Water.	Mineral matter.	Dry nitrogenous compounds.	Fat.	Dry substance.	Contents of viscera.	Water.
Fat calf	4·48	16·6	16·6	37·7	62·3	3·41	17·1	14·6	35·1	64·9	3·80	15·2	14·8	33·8	3·17	63·8
Half-fat ox	5·56	17·8	22·6	46·0	54·0	4·05	20·6	15·7	40·4	59·6	4·66	16·6	19·1	40·3	8·19	51·5
Fat ox	4·56	15·0	34·8	54·4	45·6	3·40	17·5	26·3	47·2	52·8	3·92	14·5	30·1	48·5	5·98	45·5
Fat lamb	3·63	10·9	36·9	51·4	48·6	2·45	18·9	20·1	41·5	58·5	2·94	12·3	28·5	43·7	8·54	47·8
Store sheep	4·36	14·5	23·8	42·7	57·3	2·19	18·0	16·1	36·3	63·7	3·16	14·8	18·7	36·7	6·00	57·3
Half-fat old sheep ...	4·13	14·9	31·3	50·3	49·7	2·72	17·7	18·5	38·9	61·1	3·17	14·0	23·5	40·7	9·05	50·2
Fat sheep	3·45	11·5	45·4	60·3	39·7	2·32	16·1	26·4	44·8	55·2	2·81	12·2	35·6	50·6	6·02	43·4
Extra fat sheep ...	2·77	9·1	55·1	67·0	33·0	3·64	16·8	34·5	54·9	45·1	2·90	10·9	45·8	59·6	5·18	35·2
Store pig	2·57	14·0	28·1	44·7	55·3	3·07	14·0	15·0	32·1	67·9	2·67	13·7	23·3	39·7	5·22	55·1
Fat pig	1·40	10·5	49·5	61·4	38·6	2·97	14·8	22·8	40·6	59·4	1·65	10·9	42·2	54·7	3·97	41·3
Means of all	3·69	13·5	34·4	51·6	48·4	3·02	17·2	21·0	41·2	58·8	3·17	13·5	28·2	44·9	6·13	49·0
Means of 8 of the half-fat, fat, and very fat animals...	3·75	13·3	36·5	53·6	46·4	3·12	17·4	22·4	42·9	57·1	3·23	13·3	29·9	46·4	6·26	47·3
Means of 6 of the fat, and very fat animals	3·38	12·3	39·7	55·4	46·6	3·03	16·9	24·1	44·0	56·0	3·00	12·7	32·8	48·5	5·48	46·0

[ERRATUM. Page 106, Vol. I., 4 lines from bottom of second column. For "24 parts of oxygen" read "32 parts."]

HOROLOGY.—IV.

By I. Herrmann, late Teacher of Technical Science to the British Horological Institute.

THE LEVER ESCAPEMENT (*continued*).

We will now proceed to consider the conditions of roller and lever contact, or roller depth. We have seen that the position of the lever-notch and the exit of the pin therefrom takes place when the lever rests against either one or the other banking-pin, and we have also seen that impulse is imparted by contact of either side of the lever-notch with the ruby-pin *h* (see Fig. 8, page 364). Suppose now that the drop of an escape-wheel tooth on to either locking-plane, and contact of lever and either banking-pin was at the same angular point, it will further be seen from what has been said that the length of lever-notch must be so adjusted that the pin *g* is liberated therefrom.

Conceiving now the balance to return and to effect the unlocking, we see that such will be accomplished before the pin has entered the notch, so as to permit a fair contact between either side of the notch and the pin; and hence for this reason, it is obvious, in order that the pin may fairly enter the notch before impulse commences, the notch should be sufficiently long. This, however, could not be the case in the last given condition of lever and banking-pin contact, because, if it were so, the pin could not leave the notch; hence we require an angular movement of some one or two degrees after the wheel is disengaged.

There is, however, one other reason for such, which brings me to speak respecting the connection of the pin *g*, called the "guard-pin," and the circumference of roller.

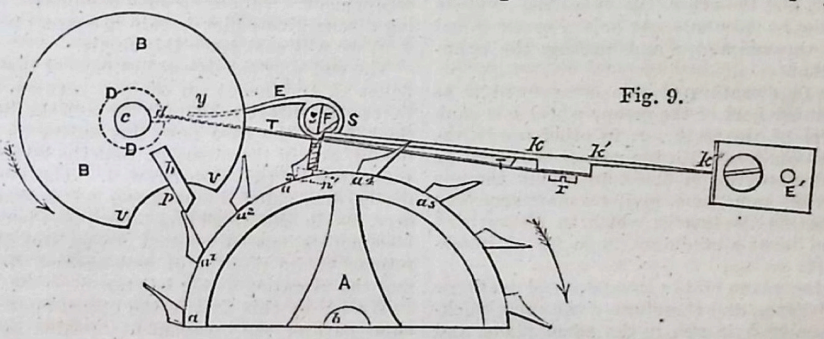


Fig. 9.

If we suppose the lever at rest against either banking, and the pin *h* out of the notch, we can easily conceive that, if by any occurrence the lever should change position to the other banking, the ruby-pin in returning, instead of entering the notch, would strike the back of the lever, and the watch would stop. To prevent this error the guard-pin *g* is contrived, and its office is as follows:—Supposing that under the circumstances last described, any force endeavoured to misplace the lever, the pin *g* would thereby come immediately in contact with the circumference of the roller, and by contact of an escape-wheel tooth with either locking-plane, would bring the lever back again to the banking. In the course of the action of the escapement, the pin *g* never comes in contact; and in order to prevent the slightest contact taking place, the crescent is cut into its circumference as shown in the diagram. The pin must therefore be at such a distance from the roller that there is a certain amount of play; but that has its maximum, and should never be so much as to allow either locking-edge of the pallet to pass the periphery of the escape-wheel, the effect of which would be that the escape-wheel tooth, passing on to the driving-plane and repelling the pallet, would thereby press the guard-pin against the edge of the roller, and stop the watch. The guard is safest when the ratio of radius of roller circumference and radius of guard-pin *g* is at a minimum; hence, to bring the position of the pin as forward as possible, the face of the ruby-pin is often flat, in order to avoid the necessity of a deep notch in the lever.

In order, therefore, that there be sufficient freedom between guard-pin and circumference of the roller without producing this error, it is further necessary, in addition to such being required by the roller depth, that there should be a small angular movement after disengagement, or locking and banking contact. The angular position of the pallet also requires attention. The roller-depth requires, as I think will be easily seen from what has been said, that the lever should move just as far from one side of the line of centres as it does on the other, before it banks against *r* and *r'*.

In relation to this motion, the pallets require to be placed on the lever so that we have the same angle of locking penetration on one side and the other, that is, the locking-edges are alternately the same distance from the centre of the wheel when the teeth become disengaged; otherwise, we have an excess of locking on one side, and on the other the evil and its result of the drop and banking at the same moment.

The driving-planes *n* and *n'* are variously constructed, to give an angular impulse motion to the pallets from 7° 30′ to 12°, the former being applied to best watches, and the latter to common, as not requiring such careful and close adjustment. The impulse-arc of the balance is variable from 30° to 45°, and is determined by the radii of lever and roller. The former is to the latter as the sine of the angle formed by the latter with the line of centres is to the sine of the angle formed by the former with the line of centres. On an average, the following short rule will suffice:—Take a piece of thin brass, and drill two holes at the same distance as the balance and pallet centres; divide the distance in four parts; take one part as the radius of the ruby-pin, and the other as the distance of lever to notch, plus the half thickness of ruby-pin to be used.

We will now briefly state a few modifications.

The principal modification is the "club-tooth." The driving-plane is divided, and half given to the tooth, the advantage of this being that little or no drop off the delivery is necessary, because the tooth, being thick or broad, can be hollowed out for clearance. Another consists in a wheel carrying the whole locking and driving-planes, and the pallets consisting of two fine long teeth in some cases and pins in others. The advantage here is that contact is continually given at the same distance from pallet-centre, which is not the case in other pallets. Another modification, called "Cole's resilient," consists in the bending of the extreme points of the teeth back, the wheel going or rotating reverse to others, by which the banking is effected against the front of the teeth, and the guard-pin dispensed with.

The principal modification of the roller-action is the double roller. It is found of advantage to have a short balance arc of impulse, which is effected by increasing the ratio of lever and roller radii. By this, however, the guard-pin contact becomes unsafe in proportion to their respective radii, and hence an extra roller is applied for the guard only.

Another modification, of a number, is the two-pin action. By this the guard-pin gives impulse also by a fine square notch in the circumference of the roller, a pin being drilled on each side of the roller-notch to effect the unlocking. By this arrangement we get a maximum impulse with a minimum resistance, which, if carefully adjusted, is an excellent modification.

Others might be mentioned, and many points more clearly and extensively treated, but the limited space at our command obliges us to proceed at once to

THE CHRONOMETER ESCAPEMENT.

In our second article we have given the outlines of the conditions on which the relative merits of the escapements depend, and it is unnecessary now to speak on this point again. Therefore we shall proceed with the chronometer escapement in the same way in which we treated the lever—viz., with a description of its sections and the action of its mechanism.

In Fig. 9 A is the escape-wheel, with fifteen teeth on its rim, *a*, a^1 a^2, and so on, with a circular hole at *b* for securing its position on the escape-pinion in the same manner as the lever escape-wheel is fastened. B B is a steel roller, called the impulse-roller, of the same thickness as the escape-wheel teeth, and fixed firmly on to the balance-staff, which passes through a circular hole, at *c*. The circumference of this roller is broken by a crescent, *v v*, whose chord is about that of two teeth of the wheel. The arc of this crescent is further broken by a

rectangular notch, with which a jewel, *h*, called the impulse-pallet, is connected. The face, *p*, of this pallet is rectilinear with the radius of the roller, in whose circumference its extreme point lies.

Beneath this roller, and fixed to the balance-staff in the same manner, is a second roller, called the discharging or relieving roller, as delineated by the dotted circle D D. This roller also has its circumference broken by a rectangular notch, into which a jewel, *d*, called the discharging or relieving pallet, is inserted. The face of this pallet points in the opposite direction to the face, *p*, of the impulse-pallet, *h*, and is also rectilinear with the radius of the roller. This pallet projects beyond the roller circumference to about one-third its radius.

E E′ is a spring of steel, called the detent, as delineated in the diagram. At E′ it is screwed to the pillar-plate, as is the case in a three-quarter-plate movement, or to a stud in a frame movement. At *s* it is of the shape of a hollow cylinder, leading off on one side into the curved part E *y*, and on the other into the straight stem *s k*.

k′ k″, which is the continuation of *s k*, is reduced to a very thin spring. The section E *y*, *s k* is also reduced to an approximation of a spring. At *r* an elevation or projection is left, upon which a gold spring, called the discharging or relieving spring, T T′, is screwed, the opposite end of which is resting upon the end E *y*. The strength of this spring is also reduced to a minimum, except the end at *y*, which is left slightly swelling. Into the hollow of the cylindrical part of the detent, at *s*, is a jewel, F, inserted, called the detent-pallet. One-half of this hollow is filled up by this pallet, and the other half by a steel or brass plug, by which the pallet is secured. At *n* is a screw called the stop-screw, passing through a stud and meeting the cylindrical section of the detent.

The vertical position or elevation of this escapement is as follows:—The rim and inner part of the escape-wheel A is sunk below the plane or level of its teeth, or, in other words, the teeth of the escape-wheel are level with the rest of the wheel on the bottom, but raised above it on the top, giving thereby broad teeth, without, at the same time, giving a massiveness to the wheel and so increasing its inertia, which in all parts of every escapement should be at a minimum, in so far as necessary stability will permit.

The roller B B is in the plane of the escape-wheel teeth, or level with it at top and bottom, and therefore of the same thickness; and the impulse-pallet *h* is also in the same plane, and therefore as broad as the roller is thick.

The detent E E′ is placed below the escape-wheel, but no lower than to give sufficient clearance, and so avoid contact. The plug *g* is also level with the top of the detent, but the detent-pallet F projects to the tops of the escape-wheel teeth. The lower part of the detent is reduced from *y* to the cylinder at E, and again from *s* to *k*, leaving the cylinder with the pallet F and plug *g* projecting below and terminating together. From *k′* to *k″* the spring is left, and hence level with the projecting cylinder. At *k″* there is a step, leaving it of sufficient thickness to give it a firm seat between the plate and head of the screw. The discharging spring covers the detent at *k k′*, but is reduced from *k* to *y*, and on a level with the recesses of the detent. The end of the detent E *y*, its stem *k s*, and the discharging spring from *k*, are therefore on the same level top and bottom, and as much below the impulse-roller B B as the detent is below the escape-wheel.

The discharging-roller D D, and its pallet *d*, are in the same plane as the end of the detent; sometimes, by reason of its thickness, it projects a little above and below. The stop-screw *n* lies below the discharging-spring, leaving a clearance between it and the spring, but not lower than the cylindrical section of the detent, the projection of which depends upon the general build of the watch. The position both of the balance and escape-wheel is secured by jewellings, as described in the lever escapement.

We shall again adopt our former method, and describe the action of its mechanism before we treat on the relative positions in plane and ratios of its sections.

Our illustration shows the escapement in repose, or the relative rotary positions when the watch is not wound up. Supposing now the winding effected and force transmitted to the escape-wheel, and we will trace the result.

The escape-wheel is moving in the direction indicated by the arrow. Tooth a^1 is in contact with the face *p* of pallet *h*. Discharging-pallet *d* of roller D D is likewise in contact with the end of discharging-spring T T′. By reason of contact of tooth a^1 and impulse-pallet *h*, the roller B B turns about its centres until the point of intersection of the arc of contact of escape-wheel and roller is reached (see description of roller and lever action of last escapement), when contact ceases, and the escape-wheel is released.

The detent E E′, when by reason of the rotary position of discharging-pallet *d* contact has ceased, rests by the projecting cylinder against the stop-screw *n*, which is so adjusted that the detent-pallet F penetrates the periphery of the escape-wheel measured from *k″* by one to two degrees. As both the impulse and discharging rollers are fixed on the balance-staff, it follows that both rotate together, and hence pallet *d* is moving in the same direction as pallet *h* during contact with tooth a^1, and so with the latter is progressive in contact with discharging-spring T T′, and under the same conditions. The length of this discharging-spring in relation to its centre of motion (such lying between *k′* and *k″* during its motion in this direction) is so adjusted that contact between it and discharging-pallet *d* ceases, and the detent returns to its repose before the escape-wheel becomes disengaged from the impulse-pallet *h*. And so, when it is relieved, detent-pallet F, having taken its position within the periphery of the escape-wheel, in its turn receives the contact of escape-wheel tooth a^2. Each roller being now wholly disconnected from the escape-wheel or detent (hence its title, "detached"), proceeds on its vibration, as explained in the lever escapement. Supposing such completed, and a new one, bringing discharging-pallet *d* again in contact with discharging-spring T T′, we will next trace this result.

The end *y* of the detent lies beyond the circle of discharging-pallet *d*, and hence no contact between this and the detent takes place directly, but only through the discharging-spring T T′. Such being the case now, this spring is bent away from the detent, and in the direction that the latter cannot follow, being prevented by the stop-screw *n*. The condition of contact of discharging-pallet *d* and spring T T′ is that of two intersecting arcs, as in the wheel and roller; and hence, when the point of bisection is passed, contact ceases, and the discharging-spring returns to its position of rest against the end *y* of the detent, and the vibration of the balance proceeds.

We see by this that in the return motion of the balance the chief part of the escapement remains in repose, contact only taking place during a short arc between the discharging-spring and pallet.

Again the balance commences a new vibration, which brings the pallet *d* in contact with the discharging-spring T T′. But now the conditions are changed, and we have the same effect as if this spring and the detent were a solid piece. Resting against the projecting part *y*, the detent is acted upon immediately contact takes place from this direction. By the momentum of the balance the detent is moved, and its spring *k′ k″* comes into action. By this movement of the detent, the detent-pallet F is moved away from the escape-wheel, which is released the moment its periphery is passed.

The relative angular positions of the discharging and impulse pallets is such that the pallet *h* has penetrated the periphery of the escape-wheel about one degree, measured from its own centre, when the tooth a^2 (which we conceived to be in contact with pallet F) becomes disengaged, and so the pallet *h* is in position to receive contact of the next tooth *a*, when the impulse goes on as our illustration shows it, and as we have already described.

It will be observed that we have in this escapement only one impulse every second vibration, but as then the escape-wheel makes an angular motion equal to the measurement from one tooth to the other, the number of the balance vibrations are two to every tooth.

The balance resistance lies in the contact of the discharging-spring T T′ and pallet *d* during the return vibration, and in detent E E′ during the impulse vibrations, and is therefore measured by the product of the elastic force of these springs and the radius of discharging contact; hence, to make this resistance of the smallest account against the balance-momentum, we have to make spring resistance and radius of pallet contact at a minimum. There is no limit to the weakening of T T′ by reason of the mechanism, so long as it is not injured;

but as regards k' k'' it is different, because it has to bear the rotary force of the escape-wheel in its repose. During this repose the rotary position of the escape-wheel requires to be so adjusted that the impulse-roller, although its circumference dips within the periphery of the escape-wheel, clears both adjacent teeth of the escape-wheel, in order that the balance makes no contact. This position of the escape-wheel is determined by the face of the detent-pallet F, which has therefore to be at an angular measure of a tooth and a half, or 36°, or else two teeth and a half, or 60°—the former being adopted in English escapements and the latter in French, which is mostly the pivoted detent, yet to be explained.

The face of the pallet F forms about an angle of 95° with the direction of the wheel, or, in other words, an angle of 5° with the wheel-radius to point of contact, by which we get the conditions of an inclined plane; and the force of the wheel induces a very slight tendency to draw the pallet to its centre, and so holds it to the stop-screw, *n*, during its repose, as is the case with escape-wheel, locking-planes, and banking-pin in the lever escapement. It is by reason of this locking that we require the detent section k' k'' to be of maximum strength consistent with minimum balance resistance, because, if too weak, the contact being made under impact, or with a blow, the spring will bend; if outwards, the angle of pallet F is changed, and instead of being attracted is momentarily repelled, the result of which is, the escape-wheel is unduly released, and comes in contact with the circumference of roller B B, and thereby either produces irregularities, or causes the watch to stop. This error, called tripping, is also produced if there is much space between the detent and the wheel. The distance of the contact of wheel and pallet from that of detent and stop-screw being great, and the effect of the impact of wheel and detent-pallet contact being greater than the rotary force during repose, draws the pallet nearer to the wheel than can be sustained, whereby the spring is twisted, which in the act of re-establishing the equilibrium reacts in the opposite direction, and so throws the pallet beyond the periphery of the wheel. It may also occasionally happen if the discharging-spring is left too strong, because, when released by pallet *d* on its return motion, it returns to the detent section *y* with a blow, and if strong will throw the latter outward. By reason of this blow it may here be mentioned that no sharp edge must be left on *y*, otherwise it will cause the destruction of spring T T′.

The impulse-angle of the roller B B varies from 30° to 40°; that is, the angle moved through by the impulse-pallet *h* in contact with one tooth is generally designed at some angle within those limits. The angular measurement of the clearance between the roller and two respective teeth of the escape-wheel is an average of one degree each side; therefore, as in a wheel of fifteen teeth the angular measurement of two teeth is 24°, we have an impulse contact of 22°; and therefore the ratio of wheel and roller radii is inversely as the sines of half these angles—or, in plain figures, for roller impulse-angle of 40°, with an escape-wheel of one inch, that of the roller would be ·55.

The ratio of detent and discharging radius would require a more complicated formula, because of the variable centre of motion, hence we will only mention the principal conditions. We have stated the reason why the detent must return to the stop-screw before the impulse-contact ceases. As with a definite detent arc, a small roller would require a larger corresponding angular movement of the balance than a larger roller, and as the balance-arc of discharging contact is controlled by the impulse-arc, it follows that the smaller the discharging-roller the more delicate is the contact, and the more unsafe. But, on the other hand, by a larger roller we increase the roller factor of resistance; therefore in determining these ratios these are the points of limitation.

In Swiss chronometers the detent is mostly mounted on pivots, like the pallet-staff in the lever escapement, and is then kept in its position against the stop-screw by a spiral spring fixed to its staff. Here we have more constant conditions, and may define the ratio of detent and roller radii as 1 to ·084.

If the reader will consider these points, he will readily perceive that it is a very delicate escapement, requiring great skill in making, careful wear, and practised hands for keeping it in order, and hence costly to manufacture and to maintain. There is, however, one great drawback to it for general use, arising out of the very principle which gives it the advantage at its minimum perturbation of balance momentum—viz., its only receiving impulse every second vibration; hence a chronometer and a rough-wearing proprietor are often a plague to a watchmaker for this cause; therefore, a chronometer is an escapement for a scientific and not for a popular watch, and any attempt to overcome this difficulty deprives it of an element of its merits.

A very complicated modification of the chronometer escapement to remedy this evil, and to make it more fit for a popular watch, was invented by an American, and patented and manufactured in this country, and called the "double-impulse chronometer escapement." But while it deprived the chronometer proper of its simplicity and advantage, it added delicacy and difficulty of construction, and hence, by its cost of manufacture, expense of maintaining, and limited result for time, defeated its own plan, and so left the chronometer master of the field.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XIX.—SCHOOL MUSEUMS (*continued*).

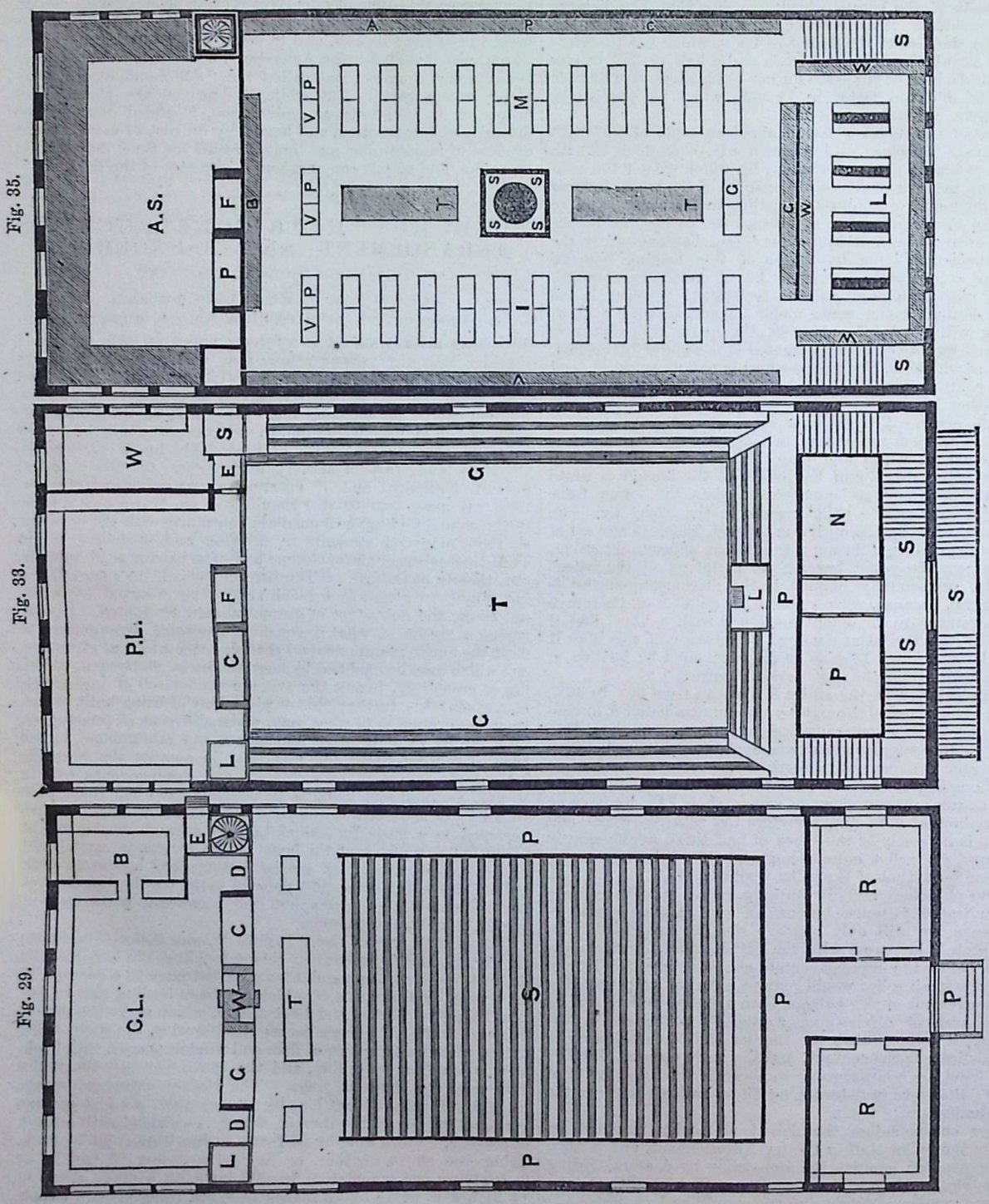
CONSTRUCTIVE DETAILS OF A SCHOOL MUSEUM.

As I have already stated in a former paper on this subject, I consider that any serious attempt at science-teaching in our great schools would require a large *lecture-theatre* (the exact size being suited to the average muster-roll); a *museum*, wherein can be permanently and openly displayed all materials employed in giving instruction, so that the same may be always accessible to studious boys at seasonable hours; *Chemical*, *Physical*, and *Natural History laboratories*, for the practical pursuit of science; and, if possible, an *astronomical observatory*. If space permitted, I should give an Arts school a place in the same building, in immediate contiguity with the museum, so that advanced students in drawing and modelling might avail themselves of the skeletons and external forms of animals, etc., therein contained. "The Science School," as such a building might be generally termed, should be designed for work, not show, and not a foot of ground should be wasted. In conveying a notion of what I consider a suitable arrangement to meet the above requirements, I shall describe a *typical* structure, one which may be modified by lengthening or shortening, widening or narrowing, to suit the average muster-roll of any school, or a given site; further, that it will admit of being built in sections, according as to what may, under different circumstances, be regarded as of primary importance and attainable. In one case a lecture-theatre and museum; in another the scientific laboratories; in another a library and reading-room, with a theatre and museum looming in the distance when funds were secured; in another a typical and local museum only. I have assumed as a basis for calculation an average muster-roll of about 500 boys, so that the body of the lecture-theatre should hold the entire school for special lectures and addresses, with gallery space for some 360 persons extra on the occasion of the presentation of prizes and the occasional gatherings of pupils, friends, and patrons.

The ground-plan of this "Typical Science School" is shown in Fig. 29, and represents an oblong building 105 feet long by 48 feet wide. P is a porch that gives entrance to a passage 10 feet wide, on either side of which are doors leading into rooms, R R, 17 feet by 15 feet and 13 feet high, which serve the double purpose of officers' private rooms and libraries, the walls being fitted, with the exception of door and window spaces, with bookcases from floor to ceiling, and the space beneath the tables with map and diagram trays. The 10-foot entrance passage leads to a theatre 64 feet long by 45 feet wide; a 5-foot passage borders the body of the theatre, which is occupied with a block of seats, S, 35 feet wide by 46 feet 8 inches from front to back, rising one above another, on an incline rising 13 feet in 46 feet, giving accommodation to 500 boys, an average space of 17 inches in width by 22 inches in depth being given to each. Every row would thus accommodate twenty-five boys, and every 100 boys would occupy a depth of 7 feet 4 inches. Each row of seats is approached by side-passages up the incline, which can be covered by hinged seats, when the rows are filled up. The filling of the seats would involve a certain amount of drill: each class (that containing the youngest boys first) would have to

march "in fours" as far as the entrance into the theatre, then divide right and left "in twos," each column wheeling to the foot of the incline, and then filling the seats to the middle line. Facing this block of seats is the lecture-table, T, 15 feet long by 3 feet wide and 3 feet high.

venient size. The top should be at least 1½ inches thick, clamped at each end to prevent warping; the centre hollowed out to admit the body of the lecturer; and the part immediately in front of him covered with stout sheet lead, on which corrosive bodies, etc., can be placed with impunity. The top should



PLAN FOR A SCHOOL LECTURE THEATRE AND MUSEUM OF TWO STOREYS.

Fig. 29 showing ground floor; Fig. 33 showing gallery floor; and Fig. 35 showing upper floor or museum storey. A longitudinal sectional view of a building thus constructed is shown in Fig. 37.

The lecture-table requires careful consideration as to the best construction, for on its provision to meet every requirement of the lecturer his comfort depends. There should be ample space for the proper arrangement of experiments and specimens; a table 15 feet long, by 3 feet wide and 3 feet high, is a con-

be screwed down to two blocks of cupboards, each block being 5 feet long by 2½ feet in depth; the side next the lecturer being fitted with two doors 2½ feet wide, and the front with a panel that can be used as a black board; the frame-work like the rest of the table being oak grained, the centre between the

two blocks being closed in front with a third panel. One cupboard should be divided horizontally by a large shelf, and the sides fitted with shelves 6 inches wide, for the reception of large and small apparatus immediately connected with the lecture-table, such as gas-furnaces, sand and water baths, retort-stands, supports, etc. The block on the lecturer's right hand should have one-half fitted with deep drawers for the reception of corks, bungs, tow, filtering paper, red vulcanised tubing, cloths, etc.; the other half with a large pneumatic trough of the pattern shown in section in Fig. 30. This must be placed on a shelf immediately under an opening

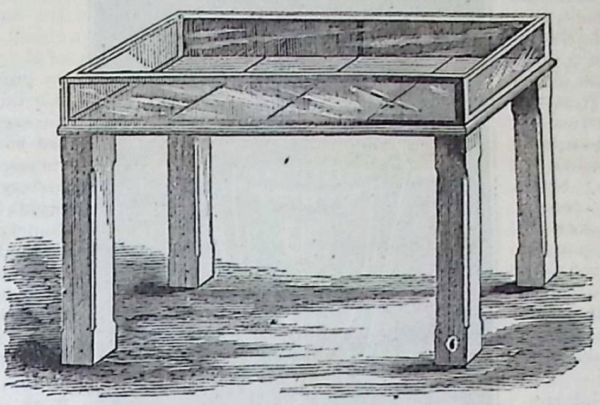


Fig. 36.—CHEAP SCHOOL MUSEUM TABLE-CASE.

physical lectures, the rule being that "there should be a place for everything, and everything in its place." A full description of such appliances will be found in that valuable modern laboratory hand-book, Greville Williams' "Chemical Manipulations." Beneath this drawer a pair of double bellows should be fixed, with the treadle ready to the foot of the lecturer; this should be fitted with a "two-way cock," and a metal tube passing therefrom to a screw-fitting let into the centre of the table-top, the second way being fitted when required with flexible tubing. Such bellows may be used for gas blast-furnaces, blowpipes, and the siren used in experi-

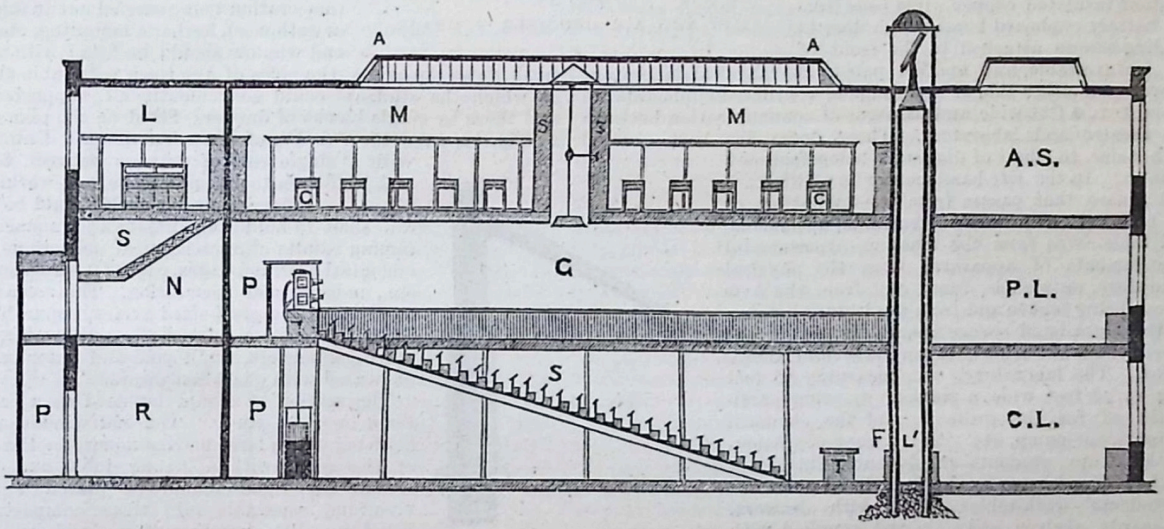


Fig. 37.—LONGITUDINAL SECTIONAL VIEW OF SCHOOL, LECTURE-THEATRE, AND MUSEUM. GROUND-PLAN OF STOREYS SHOWN IN FIGS. 29, 33, 35.

of corresponding size cut in the table-top, fitted with a removable trap. If the trough is not placed to the right hand of the lecturer, it is not in the best position for showing the transfer of gases, etc., as the manipulation would be back-handed, and the *modus operandi* not so well seen by the students. The central space should be fitted with a drawer 4 inches deep, divided for thereception of stopcocks, connectors, binding-screws, cork-borers, triangular and rat-tail files, cork knives and rasps, crucible tongs, test-tubes, holders, folded filter papers, test papers, diagram chalks, and all such appliances as may be required at a moment's notice during chemical or

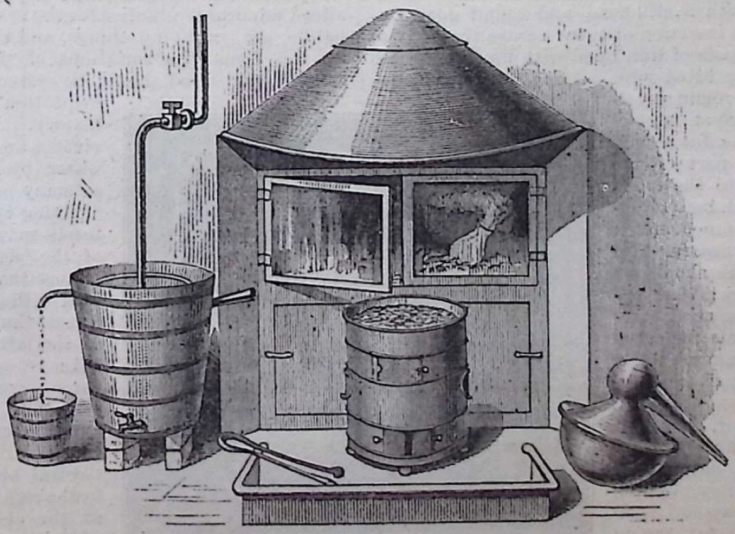


Fig. 34.—LABORATORY FURNACE SUITABLE FOR USE IN AN ORDINARY FIRE-PLACE.

ments on sound. Fig. 31 shows a telescopic universal-jointed blowpipe of simple construction that can be connected with the double bellows; and Fig. 32 a gas and air crucible furnace not hitherto described, which admits of a small crucible and its contents being brought to a white heat with that rapidity which is so advantageous for lecture demonstrations. The mixed gas and air jets point upwards and downwards on the crucible, and the whole is surrounded with a sheet-iron crucible jacket. The lecture-table must be fitted with two large binding-screws, connected by insulated copper wire with the battery cupboard.

On each side museum

table-cases are indicated. Behind the lecture-table is a projecting furnace, surmounted by a small sand-bath, the flue of which passes under and heats a long sand-bath inserted in the thickness of the wall that separates the theatre from the chemical laboratory C L, the aperture for gaining access to it being closed on both sides by glazed sliding window-sashes, W, which allow of apparatus, etc., being passed to and fro between the two rooms, and chemical operations being seen in action without obnoxious fumes passing into the theatre. To the left hand is a similar glazed recess, G, for the reception of a large series of Grove's or Bunsen's cells when the electric light is required. On the right a sashed "stink-cupboard," C, is fitted with a flat slate slab. Both the battery-cupboard and the stink-cupboard communicate with the flues of the furnaces, that all fumes generated may be carried off by the up-draught. A pair of stout insulated copper wires pass from the battery cupboard beneath the floor to binding-screws attached to the front of the lecture-table, and another pair to the physical laboratory above. On either side of this range of ventilated cupboards are doors, D D, 4 feet wide, and passages of communication between the theatre and laboratory. These doors are best covered with baize, to admit of diagrams being fastened to them. In the left-hand corner is a lift, L, 5 feet square, that passes from top to bottom of the building, to allow of instruments, specimens, and table-cases from the museum, experimental arrangements of apparatus from the physical laboratory, or models, casts, etc., from the Arts school, being sent to and from the lecture-theatre. In the right-hand corner a spiral iron staircase affords communication between the several laboratories. The laboratory, C L, measures 45 feet long by 20 feet wide, a portion, B, being partitioned off for the protection of the chemical balances, air-pump, etc. To prevent confusion, breakage, etc., students should enter this room on the left and leave by the right hand door.

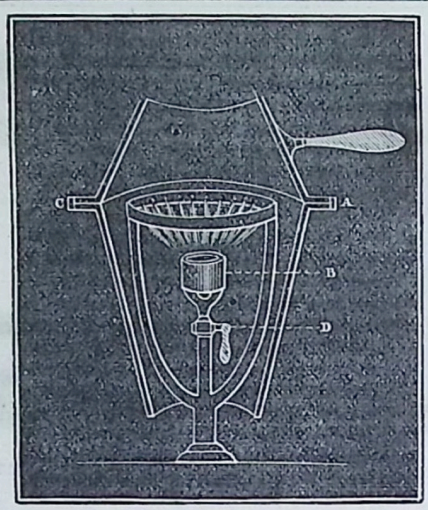


Fig. 32.
GAS AND AIR CRUCIBLE FURNACE.

Students' work-tables fitted with drawers, cupboards, shelves, and sink, and supplied with gas and water, are fitted round three sides in front of the windows, the centre of the room being occupied with large tables for general purposes. The furnace is similar to that in the theatre, the small sand-bath being replaceable with a still-head, and round doors inserted in the sides for the insertion of tubes across the body of the fire. As usual, it is made of iron lined with fire-brick, both furnace and ashpit being fitted with *sliding* doors, as such admit of being fitted close round retort-necks, etc., and give perfect control over the draught-way. The flue should pass *through* the lower part of the sand-bath on its passage to the brick chimney. As before stated, both sand-bath and stink-cupboard are common to laboratory and lecture-theatre. The space beneath the sand-bath should be closed in for hot chambers; that beneath the slate slab of the stink-cupboard serves as a receptacle for coke. All special chemical apparatus, when not in use, should be kept arranged in position in the museum.

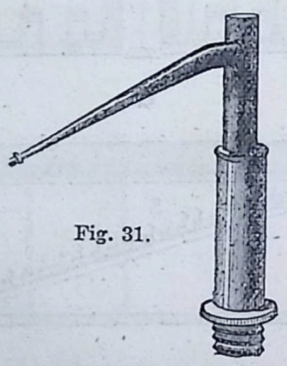


Fig. 31.
TELESCOPIC UNIVERSAL JOINTED BLOWPIPE.

The first or gallery floor, shown in Fig. 33, is approached by an external double flight of steps, S, covered by a corrugated zinc roof only, unless, through being in a very exposed position, it is deemed desirable to cover in the sides as well. To the right and left, staircases, S S, 5 feet wide, ascend to the museum floor. An entrance passage closed by doors, leads to the passage, P, of the gallery, G G, of the theatre, T, which, as previously stated, is only intended for use on special occasions. The entrance passage is formed by folding doors, which are so arranged as to allow of the two rooms, P, N, devoted to practical natural history being thrown into one on the nights of meeting of the School Scientific Society, of which this department should be the head-quarters, the entire space thus occupied being 45 feet long by 10 feet wide and 12 feet high. These rooms would be partially lighted by direct light from windows at each end, and borrowed light from the theatre and stair-passages. The section P should be devoted to the dirty work of natural history, such as the dissection of animals and plants, microscopical injections, preparations, sections, lapidary work, mounting, skeleton making (maceration being carried out in the cellar or outhouse), herbaria mounting, etc. The end window should be fitted with a large fresh-water aquarium, the sides of the room with table-shelves, at which the students could conveniently sit, supported here and there by single blocks of drawers, fitted on the plan shown at Fig. 12, page 45, Vol. IV. of THE TECHNICAL EDUCATOR, with a single row of drawers between to hold each student's tools, microscope, and working appliances. Above the table-shelf should be a narrow shelf to hold each student's jar-aquaria containing results of microscopical collections, entomological breeding-cages, cages for birds, animals, etc., under special observation. This room should be fitted with a good-sized aviary, separable into three sections; a dust-shaft, sink, water, Bunsen's gas-burners, small sand and water baths to be heated with gas when wanted.

The section N should be used as a reading-room or quiet study. The end window should be fitted with a large marine aquarium, the centre of the room with a strong table and forms. Across the room should be placed a reptile vivarium, separable into three compartments, fitted up with dwarf conifers; and an undergrowth of moss and sturdy ferns, to contain snakes, frogs, toads, lizards, newts, and other living illustrations of British reptiles. Such a work-room and study devoted to practical natural history would afford admirable practice for the systematical observation of the habits, etc., of living things, and the normal structure of dead. In this room the variations of the barometer, thermometer, rainfall, and wind should be systematically recorded under the inspection of the lecturer on natural history. By proper management of vivaria and aquaria, marine and fresh water (by no means a difficult matter, as many people fancy), a great number of living types of animal and vegetable forms may be placed before the eyes of the students. Passing on to the lecture-theatre, T, three sides are occupied with galleries, G G, the sides being 6 feet, the centre 10 feet wide, 4 feet of the latter being devoted to passage space, P. Each gallery is fitted with three rows of flap seats, similar in construction to those employed in the amphitheatre at the Royal Albert Hall, to allow of free passage between the natural history and other laboratories by the right-hand gallery through a door on the spiral staircase S. The front of the central gallery is occupied with a compartment 10 feet long by 6 feet

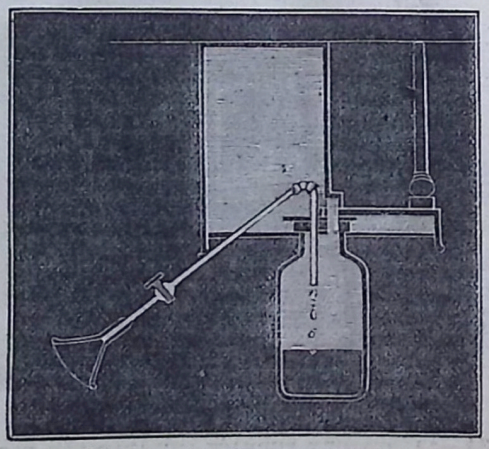


Fig. 30.—PNEUMATIC TROUGH.

wide, devoted to a dioramic oxy-hydrogen lantern, the gases being supplied from gasometers placed in a room formed by the inclined plane on which the seats in the body of the theatre are built up. The theatre is lighted by a sun-burner let into the ceiling, under a shaft passing through the roof to secure ventilation. The theatre can be instantly darkened, when lantern views are to be shown, by means of an iron shutter supported by friction rollers on two rods let into the ceiling, and which can be pulled beneath the burner or away from it by pulley and counterpoise action, worked from the lantern gallery. By the door S the physical laboratory, P L, is reached. This, like the floor beneath, measures 45 feet long by 20 wide, a portion being partitioned off for a workshop, W, fitted with carpenter's bench, lathes, circular saws, etc.; the sides are fitted with plain shelves, with a row of drawers beneath for each student's appliances. The windows in this room must be fitted with dark blinds, so that perfect darkness may be attained when needed for spectrum experiments, etc.; and one window should be fitted with a solar reflector and heliostat. Two telegraph poles should be fitted at each end of the room, to allow of wires, insulators, etc., being fixed thereon, repaired, etc., and electric telegraphs of various kinds worked by different codes. A water-tank should also be provided, for practice in (model) fuse making, torpedo firing, etc.

Besides manipulative and mathematical practice in the use of the most important physical instruments and operations, the workshop would provide means for model-making in connection with such important subjects as practical mechanics, building construction, and others. This laboratory should also be fitted with a furnace at F, but may be of a cheaper and simpler character than the one in the chemical laboratory, as it would chiefly be used for the heating or fusion of metals, etc., corrosive fumes being inadmissible where physical instruments are employed. As this form of furnace is also well suited for adaptation to an ordinary fire-place, where provision cannot be made for a special chemical laboratory, I show it in Fig. 34. It consists of a circular core or ring of fire-bricks, cased with stout sheet iron, filled with sliding doors, tube-holes, handles, and circular sand-bath, as shown in detail; above this a sheet iron hood is fixed, the wall behind the apex being pierced with a three-inch hole to carry off all fumes by the up-draught in the chimney created by the furnace fire. The aperture of the fire-place may be filled up with a sheet-iron case, the lower part being used as a warm chamber, the upper part, with glazed doors, as a stink-cupboard. The sand-bath may be replaced with a still-head. The recess C (Fig. 33) may be fitted up for the reception of apparatus in constant use, but all other physical instruments should be kept displayed in position in the museum, so that their several parts may be inspected with facility by students, when they are not in use for lectures or class work.

The museum or second floor is shown in Fig. 35. Besides a space corresponding with the theatre beneath, viz., 64 feet long by 45 feet wide, devoted to the "Typical Collections," that corresponding to the natural history laboratory and passage beneath, viz., 35 feet long by 15 feet wide, is devoted to the "Local Collection," L, the centre being occupied by the ventilating and gas-burner shaft, S. The sides are occupied by wall-cases, 7 feet high by 2 feet deep—the right-hand cases, C P A, being devoted to chemical and physical instruments, and illustrations of applied science; the central end-case, B, to botanical illustrations and vegetable types; the left-hand case, V, to vertebrate types; the lower end-case, G, to stratagraphical, geology, etc. The floor of the museum is occupied with table-cases of a standard size, 4 feet long by 2 feet wide and 3 feet high, arranged in pairs, end to end—the series on the right hand M, being devoted to the illustration of the principles of mineralogy, systematic mineralogy, rock specimens, metallurgical and economic mineralogy; the upper end-case, B, to vegetable morphology, physiology, and economic botany; the left-hand series, I, to animal morphology, physiology, invertebrate type forms, and economic zoology; the two central end-cases, G, to small characteristic fossils; tables and forms being placed at T T for the convenience of students. A *cheap school-museum table-case* is shown in Fig. 36. It consists of a bottom made of well-seasoned wood, screwed and glued to a frame fitted on three sides and the top with glass-plates puttied in air-tight; the back being closed by two hinged flaps fitting air-tight on stout felt cushions, to allow of the specimens in their trays being pushed in, four of which cover the bottom, such trays being divided with black-pinned fillets, according to the system described at page 46, and shown in Fig. 16, Vol. IV. of THE TECHNICAL EDUCATOR. This case is supported on four square legs, fitted with countersunk porcelain castors, to allow of its being moved smoothly from its proper place in the museum to the lift, by which it is conveyed to a position beside the lecture-table. The size recommended, viz., 4 feet by 2 feet, and 3 feet high, is very convenient, with the view of taking the specimens as they are arranged from the museum straight to the lecture-theatre without their being in any way unnecessarily disturbed. The space beneath can be conveniently occupied with blocks of store-drawers, constructed and arranged on the plan previously shown in these papers.

The room containing the local collection would be fitted on three sides with wall-cases, as shown at W, the fourth side being occupied with windows. The floor would be occupied with table-cases of similar arrangement to that shown at Fig. 11, page 45, Vol. IV. of THE TECHNICAL EDUCATOR, measuring 6 feet long by 4 feet wide, 3 feet high at the lower part, and 5 feet high in the centre; the space beneath being fitted with drawers on the plan shown at Fig. 12, page 45, Vol. IV. The wall-cases should contain specimens illustrative of local botany, fishes, reptiles, birds, mammals, geology and archæology; the table-cases of mineralogy, petrology, small fossils, botany, invertebrata, birds' nests, eggs, and the smaller archæological specimens. The space in front of the windows should be fitted with a table, on which specimens from drawers could be examined and microscopes placed ready for use. The windows might be made ornamental by border frames filled with magic-lantern views of local ruins, or other subjects of archæological interest. The height of the museum is 12 feet to cornice, the larger section being lighted from above by side-lights in the angle of a raised roof, similar to those found so efficient at the College of Surgeons, as previously described. The space above the wall-cases should be occupied with diagrams, wall pictures illustrating natural phenomena, etc.; in the local museum with geological sections and the maps of the Government survey of the district, etc. The museum communicates with the Arts School by the door D. This department should be fitted on three sides by windows, and with a top-light. Both walls and windows should be covered by movable curtains, of a dark mulberry colour, running on rods, to admit of proper adjustments of light and shade. Models of the best examples of statuary, vases, and bas-reliefs should be ranged around the room on pedestals, etc. Each student should be provided with a separate stool, to allow of studies, etc., being made from different aspects, or so that the entire class could be grouped in the best position around any subject, while the Arts master demonstrated special points for study. The compartment marked P should be fitted up for the practice of photography, while F will contain an ordinary fire-place. Access to the astronomical observatory would be obtained by the step from this room.

A longitudinal section through this science school building is shown in Fig. 37. The ground floor shows the disposition of the porch, P; the library and officers' rooms, R; the five-foot entrance passage into the theatre, P; the inclined range of seats, S, which should be supported by iron struts, similar to those employed at the Great Exhibition of 1851; the lecture-table, T; the furnace, F; the block L′ containing the lift-tower, placed between the theatre and the chemical laboratory, C L. The lift-tower, built within an outer tower, to meet the requirements specified for an astronomical observatory, is shown in section. The first floor shows the landing and stairs, S, leading to the museum, the practical natural history laboratory, N; the four-foot passage, P, leading to the galleries of theatre, G; the lantern room; and the physical laboratory, P L. The second floor shows the local collection, L, the typical museum, M, the ventilating shaft, S S, which consists of a central cylinder passing through the roof, crowned by a cowl, fitted just above the museum floor with a close-fitting door to give access to the gas-burner, for lighting, cleaning, repairs, etc. This cylinder is cased with a square wood guard, the exterior of which may be utilised by being covered with large diagrams, one side being fitted with a door. A A represents the angle lights above the ceiling; A S shows the "arts school," with its top-light.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Gallety, Curator, Industrial Museum, Edinburgh.

VI.—MANUFACTURE OF WOOLLEN CLOTH (*continued*).

Boiling.—This process, called "roller boiling," was introduced about fifty years ago. Although a simple operation, it nevertheless effected a wonderful improvement on the finish previously given to fine cloth, as it produces a permanent lustre on its surface which is not spotted by rain. The cloth is wound tightly round a roller, which is then made to rotate slowly in a tank of hot water for several hours. Afterwards it is placed in a cool atmosphere, or immersed in cold water for a longer period, and this treatment is repeated several times. There is a way of shortening the process by winding the cloth round a perforated metal cylinder, and allowing steam to pass through it. Among Continental manufacturers there are other plans in use, chiefly by means of pressure and steam, for giving a lustrous finish to woollen fabrics.

Pressing is the only other process we need specially notice. The first pressing is given to the cloth before the roller-boiling after it has been brushed by revolving brushes. For this purpose the cloth is folded up in regular lengths, with glazed paper between the folds to prevent the surfaces of the cloth from coming into contact. Hot iron plates are then introduced between each folded pile of fifty yards, and when a sufficient thickness or height is made up the whole is subjected to the action of a powerful screw, or, more usually, a hydraulic press. For superfine cloth the plates are but slightly heated, and the second pressing is given with the plates cold. Some inferior cloths receive a surface lustre from strong compression with highly heated plates, without being boiled or steamed at all, but when so treated they are easily disfigured by rain.

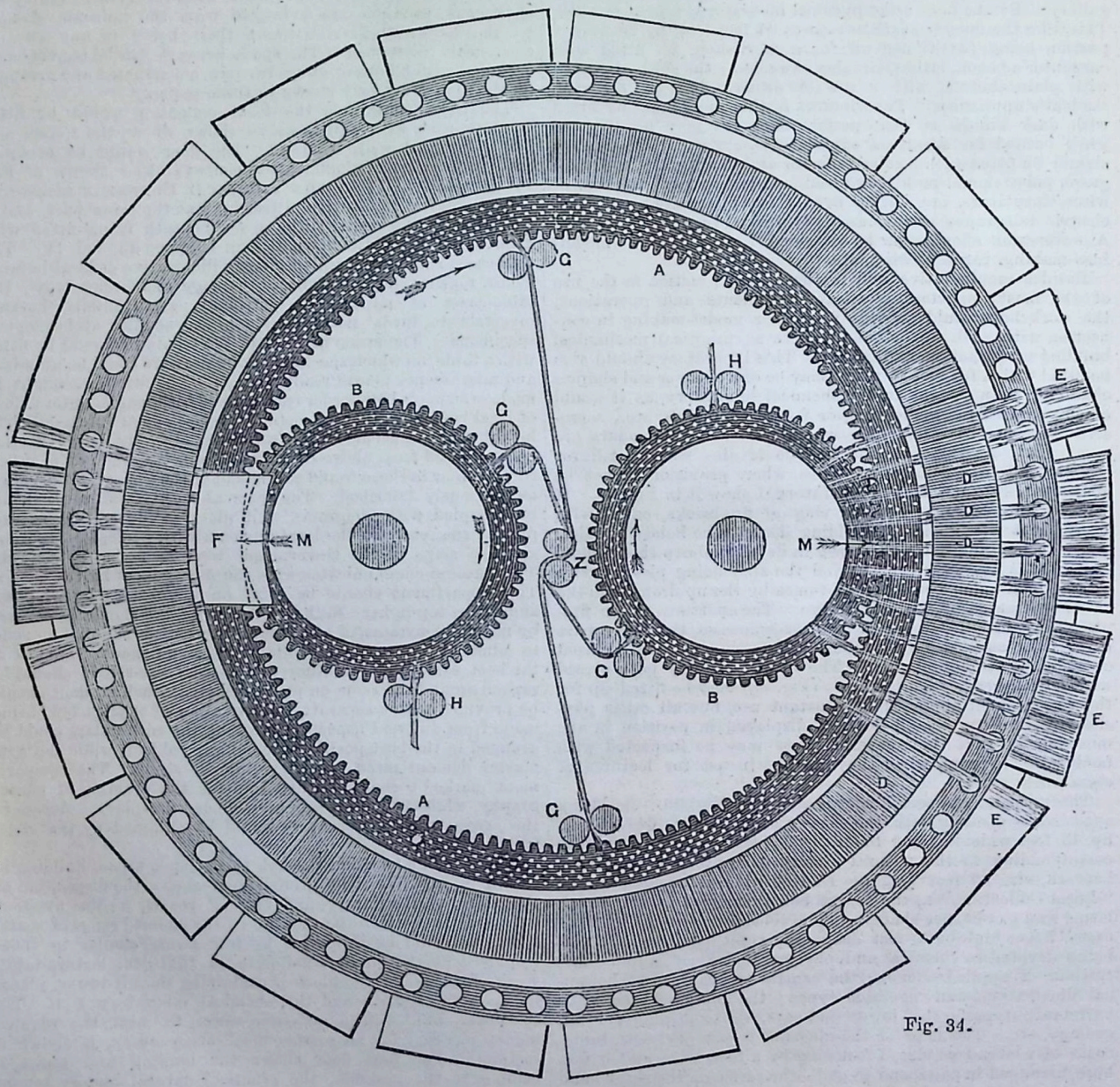


Fig. 34.

MANUFACTURE OF WORSTED CLOTH.

Having concluded our description of the more important of the multifarious processes in the manufacture of woollen cloth, we will now give an outline of the operations in a sister industry—namely, the worsted manufacture—the extraordinary development of which is one of the wonders of our time, and in which, so far as cheapness, variety, and extent of production is concerned, England surpasses any other country in the world.

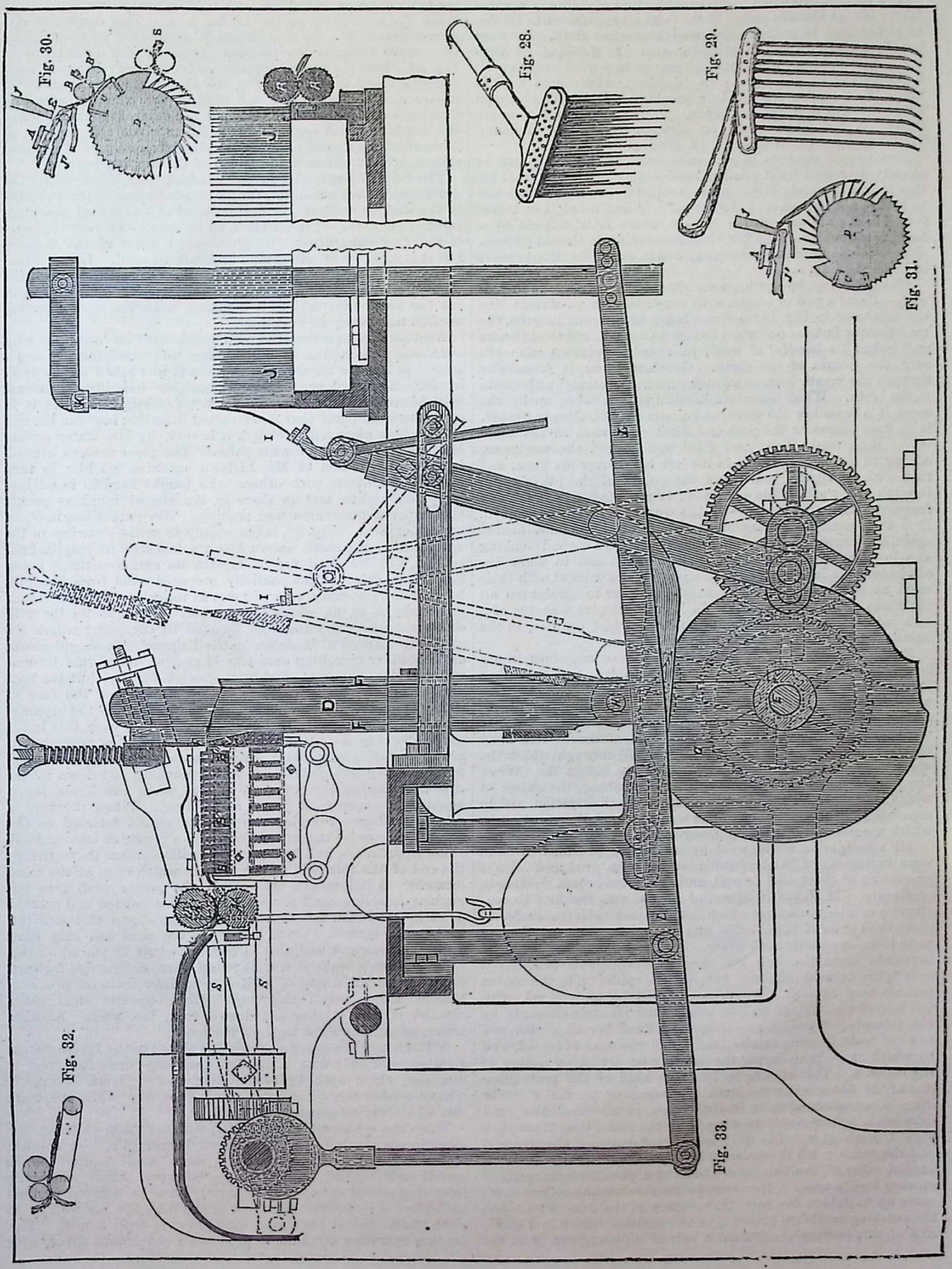


Fig. 30.
Fig. 28.
Fig. 29.
Fig. 31.
Fig. 32.
Fig. 33.

The various processes in the manufacture of ordinary worsted fabric are, as already stated, fewer, and more reduced to mechanical precision than those practised for woollen cloth. They are usually as follows:—1. Sorting the wool. 2. Washing. 3. Drying. 4. Plucking, when the nature of the wool requires it. 5. Preparing by gill-boxes. 5*a*. Carding, when short wool is used. 6. Combing by hand or machine. 7. Passing combed sliver through finishing gill-boxes. 8. Drawing, say five or six times. 9. Spinning chiefly on throstle-frame. 10. Reeling. 11. Warping. 12. Weaving. 13. Dyeing.

Sorting and *washing* is performed much in the same way as already described for "woollen" goods, but "the long wool for this branch is rarely dried out so completely, so that a tendency to curl is not imparted to the fibres." When dried it is transferred to a machine called a *plucker*, where it is cleaned by a fanning apparatus, and after which, according to the old system, changed as it were but yesterday, it was ready for the process of hand-combing.

Hand-combing is—perhaps we should say was—done in this way:—Using a pair of combs, with two or three rows of teeth, like the one shown in Fig. 28, each row being of different lengths, the wool-comber fastens one when heated to a post, and then throws or "lashes" a handful of wool, previously sprinkled with oil, over the points of the teeth. He then draws it repeatedly through the comb, leaving at each pull a few straight filaments in the teeth. When the whole handful is thus taken up by the comb it is heated in the stove, and another comb, already heated, is in turn placed on the post and filled with wool in the same way. Both combs being now filled and heated, the workman, sitting on a stool, holds one in his left hand over his knee, and then with his right hand draws the points of the other comb through the wool. This operation is repeated—the workman frequently changing hands—till the wool is sufficiently combed. It is then nearly all transferred to one of the combs, heated again, and drawn off in a sliver which receives a second combing at a lower temperature. Care must be taken not to allow the combs to come into contact, although they are worked with their teeth as closely together as possible in order to straighten all the fibres of the tuft or tress. In Fig. 29 we give a sketch of a rude wool-comb used, up to the middle of last century, in the Shetland Isles: the handle is entirely of horn.

Machine-combing.—There are two classes of machines in use for wool-combing, one suitable for long-stapled, and the other for short-stapled wool. In the case of long-wool combing it is necessary, in the first place, to straighten or stretch the fibres, and also to separate or open them. This is done upon a series of "preparing gill-boxes" (a gill is a kind of comb with steel teeth), so arranged that each succeeding gill through which the wool passes has finer teeth than the one before it. When the wool is thus prepared it is ready for combing, the object of which is to place all the fibres in a longitudinal direction, and to separate the short portions of the wool, technically called *noils*, which are not suitable for spinning into worsted yarn.

All attempts to comb wool by machinery previous to 1846 were imitations of hand-combing, and, like it, produced a large proportion of short wool or noil, and were more or less wanting in continuity. M. Josué Heilman, of Alsace, was the first to construct a combing-machine which could detach tufts from a fleece, comb both ends of these tufts, and then piece them together so as to form one continuous sliver. Heilman's machine is a most ingenious invention, and has been of incalculable benefit not only to the worsted industry, but, for fine spinning, to the cotton manufacture as well. Its principle will be understood, with the help of Figs. 30, 31, and 32, which show its main elements, by the following description:—There is a fixed bar at A with two rows of teeth forming combs into which the wool is forced, and by which it is held during the drawing or detaching action of the roller B. This nipping-roller takes hold of the protruding end of the fleece when the plain or projecting portion C of the drum D comes round to it in the course of its revolution, and detaches a tuft of wool, drawing it at the same time through a second comb at E. The tuft is engaged between the drum D and the roller B till it is carried between the latter and its companion roller B′, the two rollers then by a peculiar arrangement moving bodily away. However, before the drawing-rollers B, B′, move up to detach the tuft, that portion of the drum D on which the combing teeth are placed is in the position shown in Fig. 31, and at this particular moment a pair of nipping-jaws, J J′, are made to close on the fleece and hold it while the drum-teeth comb the projecting portion of the wool. This done, the nipping-rollers B, B′ seize and detach it as already explained, and then move towards the position shown by the dotted line in Fig. 30, where the tail or opposite end of the tuft also receives a combing from the drum. Fig. 32 shows the arrangement of rollers and endless apron for piecing the combed tufts and forming a continuous sliver. There are several modifications of the machine which are used for peculiar kinds and lengths of fibre; thus, a grooved roller and guide-plate, or a pair of grooved rollers, are sometimes used instead of the nipping-jaws.

The "noil" separated in the combing falls down under the drum, but though unsuitable for the worsted-spinner, it is valuable to the woollen cloth-maker. Here is what a practical manufacturer says of it:—"It contains, so to speak, the very 'kernel' of the wool—the finest, though shortest fibres of the fleece—but it is often very nibby and difficult to card. Large quantities of this noil are exported to the Continent, where the woollen carding machinery is better adapted to card and open out the small nibs which it contains, than the corresponding woollen machinery in Yorkshire."

Another combing machine, now much used for combing long wool, was patented in 1850 by Lister and Donisthorpe, and a second patent for improvements upon it was taken out in 1851 by Mr. Lister alone. Lister's machine has little external resemblance to Heilman's, and yet it so closely resembles it in some essential parts that a protracted litigation between the two parties took place which ended, it is said, by Mr. Lister paying Mr. Heilman £30,000 for his patent. The great success attending the introduction of Mr. Lister's machine led him in turn into legal contests with others, who fought hard to invalidate his patent rights, and so share in the almost fabulous profits this important machine was making. The patent has now, of course, expired. Fig. 33, taken chiefly from the drawing in the specification of patent, shows Lister's machine in longitudinal section, and we shall try to explain its action without going much into detail. The partially prepared wool from the gill-boxes is fed through a pair of grooved rollers A, A′ to a series of gill-combs, B, B′, B″, which are worked by screws on the gill-shafts S, S, and carry the wool forward to the point where the gill-comb marked B″ is shown on the diagram. These gill-combs are heated by travelling over jets of gas, as when this is done not only does the wool comb with greater facility, but the heat also tends to preserve the teeth of the gills. From the face of the gill-teeth at B″ the wool is detached in tufts by the nipping-jaws C, C′, which comb the back or tail end of each tuft in the act of drawing it out of the gill. These nipping instruments are carried on a reciprocating frame D, moving freely on a shaft E, and having side-plates F, F, which move up and down by the cam G acting on the roller H, and so press the lower jaw C′ against the upper fixed jaw C as required. When the tuft is seized, the frame carrying the nippers moves forward to the position shown by the dotted lines, and a porter or carrier-comb I now approaches, and by a peculiar motion enters its teeth into the end of the tuft held by the nippers which open at the same moment. A link motion then carries the porter-comb I to the circular receiving-comb J, upon which it is deposited and pressed down by the brush K, which has an up-and-down motion given to it by the lever L. Up to this stage the wool has only been combed at one end, and now as tuft after tuft is placed on the receiving-comb, while it travels round, these are carried forward in its circuit till a pair of rollers, R R, draw them off in a continuous sliver, called the "top," their opposite ends being cleaned of noil as they are drawn from the comb. Another arrangement clears the teeth of the noil.

A Lister wool-combing machine was shown in the International Exhibition of 1871 with a circular receiving-comb, four feet in diameter, which combed fifty pounds of wool per hour. Formerly a hand-comber could not do as much in a day, while his work was much less efficiently performed.

There are some wools used in the worsted trade which are too short in the staple to be prepared on "screw gills" or combed on machines like Lister's. Such short wool requires to be carded on a carding-engine, which, however, differs materially from those used in woollen factories, since in worsted carding the object is to lay the fibres all in one direction, as well as to clean them, and at the same time preserve their length. The carding operation accordingly produces a continuous sliver, with

the fibres for the most part parallel to each other and ready for combing.

For short as well as for long-stapled wool there are several combing machines employed. One of the best in use for combing short wool is Noble's, which was shown in motion in the International Exhibition of 1871, by Mr. S. B. Walmsley, of Bradford, and of which a large number are now at work in all parts of the world where worsted manufacture is carried on. In Fig. 34 we give a kind of horizontal plan of its chief parts with the driving gear left out, the figure being only intended as a diagram. The large circular comb A is filled with several rows of teeth, represented by dots in the figure, as we are supposed to be looking down upon them, and is driven round by the outer toothed rims of the two smaller circular combs, also with rows of teeth, B, B′. These receive their motion from spur-gearing and connections, the ingenious arrangement of which regulate with great nicety all the parts of the machine. Outside of, and concentric with, the large comb there is a circle of seventy-two feeding-boxes, D, D, D, with lids, and outside this again a ring of metal with seventy-two holes. Attached to this ring, but on a lower plane, are two concentric rows of bobbins, of which only the outer one, marked E, is shown in the figure. These bobbins contain the carded slivers, and along with the feeding-boxes D, move round with the large circular comb.

The machine acts in this way. When near to the two opposite points M, M, where the large and small combs come together, and only there, the feed-boxes D, through which the slivers of wool pass freely, rise by means of a cam; and at the same time the wool is held by an iron plate, so that a sufficient length of sliver is drawn up from the bobbins and placed by the feed-boxes across the teeth of both combs. A brush, F, at the same moment presses it down into the teeth, as in Lister's machine, and then as the combs divide, a fringe or tuft is left on both combs, one being pulled by the smaller through the teeth of the larger, and the other being pulled by the larger through the teeth of the smaller. The same action of course takes place at both points M, M. After the combs divide the boxes remain down till the sliver is drawn at G, and then rise again for the next feed. A continuous sliver of combed wool, or "top," is drawn off at four different points by the rollers G, G, G, G, and wound up at Z, while the "noil," or short wool, is drawn off at H, H.

After being combed the sliver or "top" is twice passed through what are called "finishing gill-boxes." These are of a similar nature to the gills in the long wool-combing machines, and still further aid in straightening and rendering more perfectly parallel the fibres of the "top," which is now reduced in size and is ready for the "drawing" process.

As it will serve to connect the processes, we give a diagram of the elements of a drawing-frame in Fig. 35, although it is nearly the same as that used for drawing-out cotton. The difference between the two is chiefly in the distance between the rollers, and in having the means of making this greater or less in a worsted drawing-frame, so as to suit the length of the fibre. The drawing-rollers are loaded with weights in some such way as that shown in the figure, so as to prevent the sliver slipping through without being drawn out, and a suitable arrangement of toothed wheels regulates their speed. The function of the drawing-frames is to remove all inequality in the sliver or slubbing, to average and equalise it, and to reduce it by degrees to the proper size for the spinning-frame. In a drawing-frame there are several pairs of rollers so regulated that the first pair move slowly, and each succeeding pair faster than the one before them. Thus B B may move twice, C C′ four times, and D D′ six times as fast as A A′, by which arrangement the three slivers (shown in the figure by dotted lines), after being united into one, would be drawn out to six times their original length. Suppose that six instead of three slivers were drawn into one, and then extended in length six times as above, the resulting sliver R would be of the same average weight per yard as any of the original six, but with its fibres much more equally laid and less liable to tear across. This operation is generally repeated five or six times, but the precise number of drawings, as well as the extent of each, depends altogether on the fineness of yarn required. The whole extension is seldom less—usually it is very much greater—than a thousand times, which would be roundly arrived at by four drawings as follows:—1st. Six slivers drawn into one, making 6; six of these again drawn into one, making 36; six again into one, making 216; and finally five into one, making 1,080. That is to say, supposing there had been no doubling, the combed sliver would thus be drawn out 1,080 times its original length. It really is so, only several are joined together at each drawing, in order that it may be more evenly and uniformly reduced.

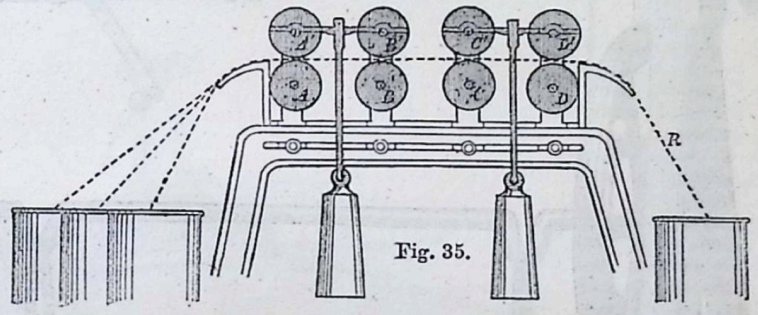


Fig. 35.

Roving and *spinning* succeed the drawing process, both of which are done upon frames similar to those used for the same operations in the cotton manufacture. In roving the sliver is still farther drawn out by rollers on the same principle as those in the drawing-frames, but owing to the great attenuation reached at this stage it requires to be twisted to save it from breaking. In spinning worsted the extension or draught of the roving is much greater than in cotton. The spinning is chiefly done on the throstle-frame, with spindles and flyers for long wools, and with spindles and caps for short wools. Sometimes, however, the mule is used, and, it is said, even largely in France.

Weaving.—Power-looms have been in use for worsted stuffs for about fifty years, yet in France, where the worsted manufacture is so successfully conducted, the number of hand-looms exceeded the power-looms even so recently as 1867. Some good judges think, indeed, that the superiority of the French all-wool goods is partly due to the skill of her hand-loom weavers. However, the recent rapid growth of the worsted industry in that country is known to be owing to a more extensive use of power-looms; and in England hand-weaving in this manufacture is a thing of the past. The perfection to which English power-looms have now been brought is shown by the fact that the worsted fabrics of France, Russia, Sweden, and Spain are to a great extent woven upon them. It is stated in Mr. Leach's report on the woollen and worsted machinery in the International Exhibition of 1871 that a single English maker, Mr. George Hodgson, of Bradford, turns out about 7,000 plain looms, such as are used for Orleans cloth, per annum. One of these will weave a yard in ten minutes, so that here are as many power-looms made in one establishment as will weave 70,159 miles of cloth in a year, or as much as would go nearly three times round the globe. In addition to these, this same maker constructs a large number of looms for weaving check and fancy stuffs.

THE LATHE.—XIX.

By Henry Northcott.

AMATEURS' LATHES.

Turning is such an interesting art, that it is not surprising its practice is very far from being confined only to engineering works. Indeed, from the earliest age of the lathe it has been a very favourite instrument of amusement with persons having leisure and a taste for mechanics; and amateur turning, both plain and ornamental, is now so extensively practised, that not only are lathes and apparatus specially designed for such work, but the construction of such mechanism has become almost a distinct business.

The distinctive features of lathes used by the amateur and ornamental turner are lightness, high finish, and the power of being applied to the execution of a great variety of work not usually performed in the lathe.

Some of the simple forms of lathe already described may be

termed amateur lathes; but the lathe best of all suited to the amateur mechanic is a light screw-cutting lathe of about five-inch centres, with treadle motion, and carefully designed slide-rest. Such a lathe as this, when provided with the necessary tools and apparatus, is capable of executing almost any kind of light work, and is altogether a most useful instrument.

Fig. 124 shows an amateur lathe made by Mr. Munro, of Lambeth. It has a strong treadle motion with two cranks and chain connections, four-speeded cone-pulley grooved for a gut-band, and driven from a fly-pulley with two sets of speeds, for fast and slow driving. The double gearing has an endway motion for throwing it into and out of gear, and the two head-stocks are neatly designed, and calculated to be very efficient in use. The leading-screw is outside the bed, and it is used for both sliding and screw-cutting, as for these small lathes separate sliding mechanism would be an unnecessary complication. A separate rack and pinion is, however, provided for traversing the slide-rest along the bed by hand.

Turning to the slide-rest, it will be seen the lower slide is a fixture at right angles to the bed; but the upper slide may be set at an angle for angular and taper turning, or it may be removed altogether; neither is self-acting, the motion being given upon the surface and angular cuts by turning the respective slide-handles.

The lathe is shown chasing up the thread of a slender screw; the arrangement of change-wheels for obtaining the pitch will be seen clearly from the illustration.

Figs. 125 and 126 are two views of a lathe made by Messrs. T. Cooke and Sons, of York, which embodies several features not hitherto exhibited in any of the lathes described. The bed is mounted in the usual manner upon two standards, except that it projects some distance out over the standard at the right-hand end. The treadle motion has a single crank only, which is placed at one end of the crank-shaft, and at the other end is a double-speeded grooved driving-pulley. The motion is conveyed to the lathe-pulley by a gut, and as the leading-screw comes rather in the way, a small guide-pulley is affixed to the bed just under the screw, to keep the gut coming into contact and rubbing against it. The face of the large spur-wheel upon the lathe-spindle is turned flat, and is converted into a division-plate by being divided at the edge, and furnished with a spring-pointer for taking into the division-holes. A division-plate is a very useful addition to a lathe of this sort, and the mode of carrying it out is very simple. The motion for screw-cutting is taken off the lathe-spindle by a series of small pinions, two of which being placed upon a rocking-plate allow the direction of the rotation of the leading-screw to be arranged for cutting a right or left-hand screw, by merely shifting one or other of them into gear with the driving-pinion. As thus designed, the socket of the lowest of the pinions takes the place of the lathe-spindle, and the wheel that would in the lathe last described be placed upon the spindle, is here placed upon this socket; the intermediate and the leading-screw wheels being arranged as usual.

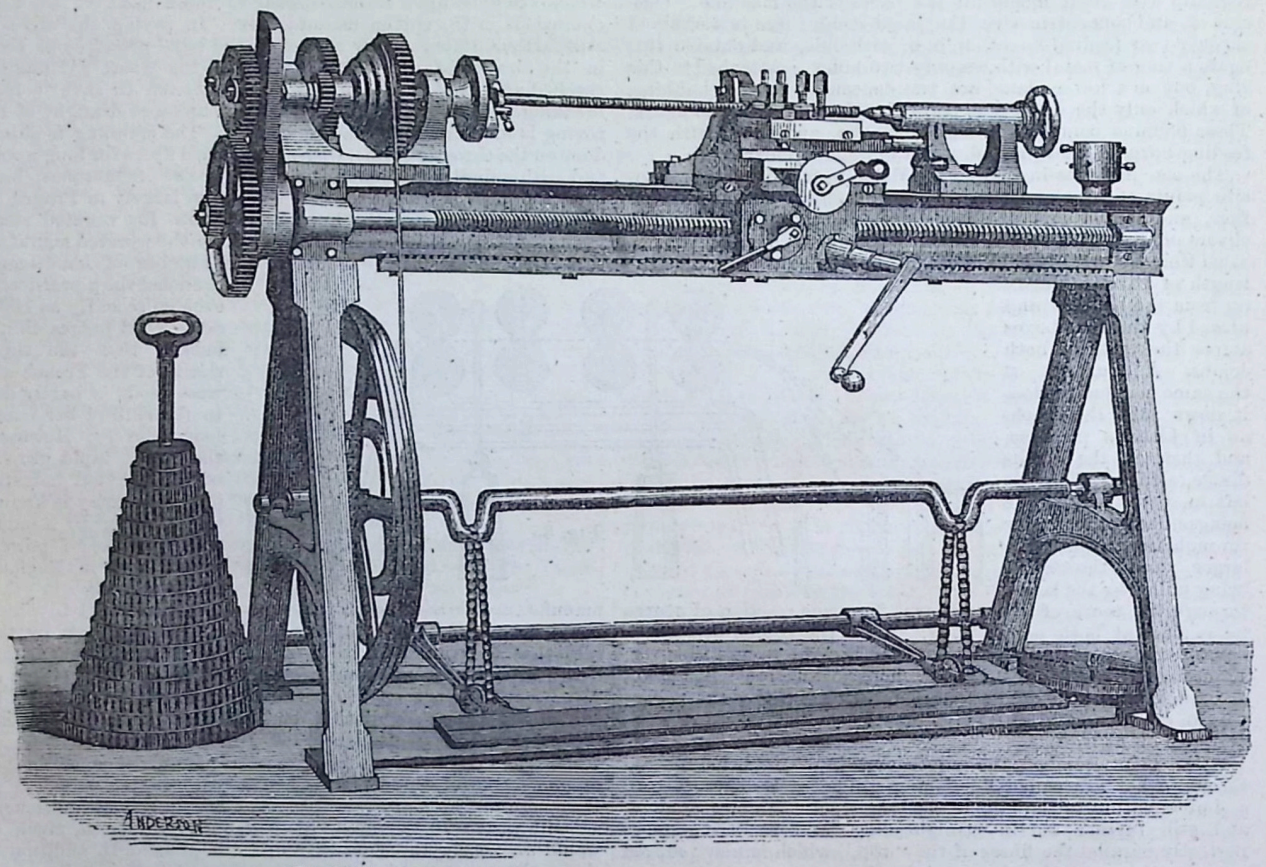


Fig. 124.—AMATEUR LATHE MADE BY MR. MUNRO, OF LAMBETH.

It is in the slide-rest that the main departure from ordinary practice becomes observable, and the present design possesses advantages that should cause it to be more generally adopted. In the ordinary plan, the rest-saddle is placed upon the top surface of the lathe-bed, which is planed and scraped up to a true surface; but the dust and shavings from the work are continually falling upon the bed-surface, and this being slightly oiled, the small particles of iron and grit adhere, and getting between the surface of the bed and saddle, cause a good deal of friction and wear. If the lathe be in the hands of a careless person who does not continually keep the sliding surfaces free from the grit thus deposited, long scratches and ruts soon become scored upon the well-scraped bed, and also in the under surface of the saddle, although they are there out of sight. Even with a careful turner the bed is sure to become scratched

sooner or later, as it is almost impossible to keep the dirt out of these slides. Messrs. Cooke's arrangement of slides is not so liable to this kind of injury, owing to the slide upon the bed being more out of the way of falling shavings, and also owing to the less surface actually exposed to receive them. This, however, is not the main advantage possessed by the outside slide.

An ordinary rest-saddle sliding upon the bed can only be moved anywhere along the bed between the two headstocks; whilst in this lathe, the saddle being hung on the outside of the bed, it may be moved along the lathe-bed past the right-hand headstock, of whose position it is quite independent. This is frequently a great convenience, as it removes the slide-rest out of the way, and shows a clear field in front of the work for the more convenient application of a hand-tool rest, and for other purposes. The mode in which the saddle is placed upon the bed will be clear from the figures. It is traversed by the leading-screw with a nut affixed to the saddle, and the hand-traverse is obtained through a handle, which by means of a pair of bevel-wheels drives round the leading screw-nut. The upper part of the saddle is fitted with a flat groove, in which is placed the foot of the compound slide-rest; this foot can be pushed in its groove either towards or from the centre-line of the lathe, so as to give any required nearness of the tool to the work, and a dovetail groove with a bolt on the under-side of the foot provides the means of fastening the whole rest down upon the saddle. There is also a rising and falling motion between the upper slides and their foot-piece, by means of which the point of the tool may be adjusted to the height of the lathe-centres. At the back of the lathe, and extending nearly the length of the bed, is a light supplementary shaft carrying some V-pulleys, as shown. The object of this is to drive certain instruments used for drilling and other purposes, which are held in the slide-rest, and which require rapid rotation to enable them to do their work.

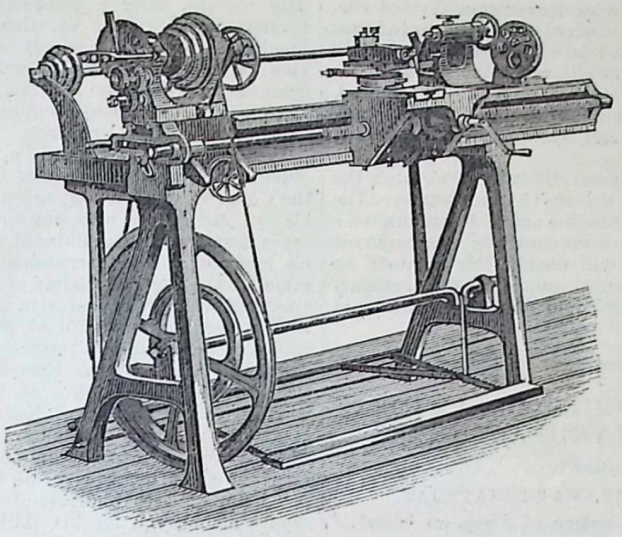


Fig. 126.—AMATEURS' LATHE, BY MESSRS. COOKE AND SONS, OF YORK.

Altogether, this is an excellent example of a lathe for light, accurate mechanical turning, and Messrs. Cooke and Son's workmanship is well known to be excellent. Another contrivance of Messrs. Cooke's, which to the amateur turner is of great assistance, is an apparatus for cutting screws in an ordinary hand-tool lathe. This contrivance, shown at Fig. 127, was invented by Mr. Cooke in 1838, and has been in daily use at his works since that time. By the use of it an inexperienced hand is enabled to cut screws, the machine giving him a true lead, after which he may finish them by turning in the usual way, the only attention requisite being the steady holding of the screw-tool on the small rest of the instrument, and giving the necessary reciprocating motion to the lathe. In use, the machine is clamped to the lathe-bed in the same way as an ordinary hand-tool rest, and as parallel to it as the eye is capable of judging. The projecting lever extends to the opposite side of the lathe-bed, along which a cord is stretched, and which being looped on to the small pin at the end of the lever, connects it to the lower part of an upright wooden pulley, the cord being kept tight by a weight at the lower end. Another cord connects the upper part of the pulley to the lathe-mandril. Before looping the cord on to the small pin, however, there should be several turns of the other cord made round the mandril. The reciprocating motion is then given to the lathe by the treadle, care being taken not to make a complete revo-

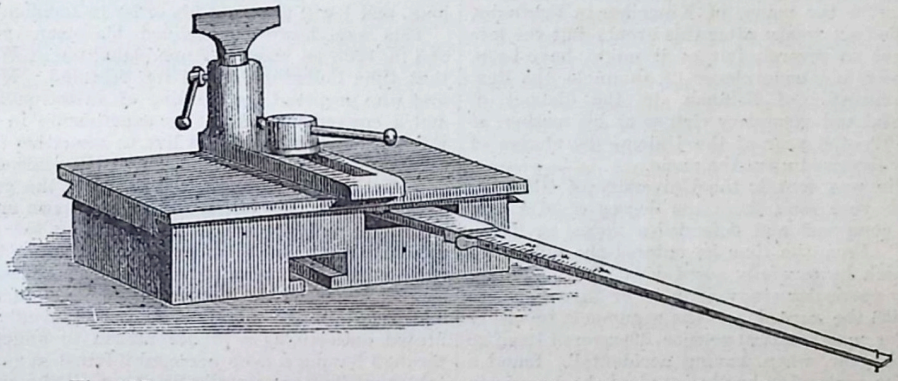


Fig. 127.—APPARATUS FOR CUTTING SCREWS IN A HAND-TOOL LATHE, BY MESSRS. T. COOKE AND SONS, OF YORK.

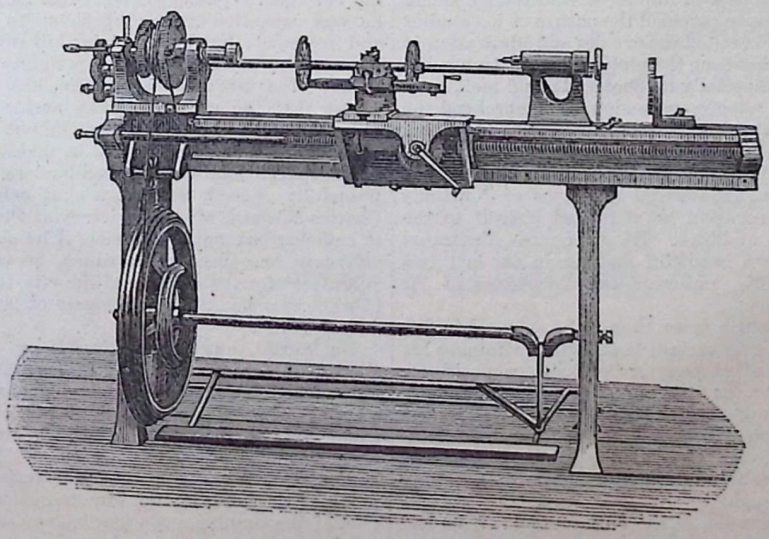


Fig. 125.—AMATEURS' LATHE, BY MESSRS. COOKE AND SONS, OF YORK.

lution of the crank. A sliding index traverses a divided portion of the lever, and when it is desired to use the apparatus, the required number of threads per inch divided into forty will give the corresponding number opposite which the sliding index should be fixed. Thus, if ten threads per inch are required, then $40 \div 10 = 4$; the index, therefore, should be fixed opposite the figure 4 of the divisions, and the corresponding screw-tool held on the rest.

In chasing screws by hand the great difficulty is to catch the pitch, and this is the object of the above contrivance. The completion of the screw, when once the spiral is caught, is a matter of no great difficulty, and a comparatively small amount of careful and steady practice will enable the amateur to accomplish this in a creditable manner and to his own satisfaction, and in far less time than he could do it without the aid of this useful apparatus.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

BY JAMES GRANT.

XLVII.—COLIN MACLAURIN, MATHEMATICIAN.

THIS eminent philosopher was a native of Tiree, an island of the Argyleshire Hebrides, twelve miles long by four in breadth, usually called by the Highlanders *Ripghacd bar fo thuin*, or the "kingdom whose summits are lower than the waves," as it is the flattest islet in that part of Scotland. Colin was the youngest son of the Rev. John Maclaurin, minister of Glenderule, and was born in the manse of Kilmodan in February, 1698. His father died six weeks after this event; but the loss to his family was not so severely felt as it might have been, owing to the kindness and benevolence of an uncle, the Rev. Daniel Maclaurin, minister of Kilfinan, in the district of Cowal, and the careful and exemplary virtues of his mother, at whose death, in 1707—the year of the Union—the charge of her orphans entirely devolved upon the uncle.

By the latter Colin was sent to the University of Glasgow, and in his fifteenth year took there the degree of M.A., on which occasion he composed and defended a thesis on "The Power of Gravity." From the time he entered the college he kept a diary, in which he carefully noted down the beginning and success of every particular study, inquiry, or investigation, his conversations with the learned, and the arguments on either side. His genius for mathematical science discovered itself so early as his twelfth year, when, having accidentally found a copy of Euclid in the room of a brother student, he became in a few days master of the first six books without any assistance. He now made an extraordinary progress, and began to engage himself in the solution of the most difficult and curious problems. The depth and boldness of the topic selected by young Maclaurin in his thesis at once revealed the nature of his studies while at the university, and excited the wonder and admiration of all who were present. At that time the philosophy of Newton was comparatively unknown, especially in Scotland; and men, even the most distinguished in science, were slow to comprehend the great and important truths his system contained. "When, therefore, young Maclaurin chose the 'Power of Gravity' as the subject of his thesis, it was a pre-supposition that he was fully acquainted with the fundamental doctrines of Newton's discoveries, and on this occasion he acquitted himself to the wonder and delight of his auditors. He afterwards illustrated the same subject in a most beautiful manner in the last two books of his account of the philosophical discoveries of Sir Isaac."

Nothing delighted Maclaurin more than to be engaged in difficult problems; and it is now certain that, before attaining his sixteenth year, he had invented many of the finest propositions, afterwards published under the title of "Geometria Organica." In 1714 he began the study of divinity; but disgusted by the dissensions which so frequently prevail in the Church of Scotland, he relinquished all idea of becoming a clergyman, and happily for science and mankind devoted himself to the study of mathematics and philosophy.

When only nineteen years old, in the autumn of 1717, he had the confidence to become a candidate for the chair of mathematics in the Marischal College of Aberdeen, and he was elected duly thereto, after a competition which lasted for ten consecutive days. In the vacations of 1717 and 1719 he went to London—a long and arduous journey in those days—with the view of extending his information; and there he became acquainted with Sir Isaac Newton, Dr. Hoadley, Dr. Samuel Clarke, Mr. Martin Folkes, and other eminent men, and was admitted a member of the Royal Society.

In 1722, Alexander, Lord Polwarth, K.T., afterwards Earl of Marchmont, then ambassador from the Court of St. James to the Congress of Cambray, selected him as a travelling tutor for his son, Mr. Hume, who was about to make what was known in those times as "the grand tour;" and while in France he wrote his essay on "The Percussion of Bodies," which gained the prize of the Royal Academy of Sciences in 1724, and the substance of which is embodied in his "Treatise of Fluxions." The sudden death of his pupil at Montpellier caused Maclaurin to return to Scotland, and resume the duties of his chair at Aberdeen. In 1725 he was chosen to succeed James Gregory as Professor of Mathematics at Edinburgh, where his lectures, which began on the 3rd of November in that year, contributed greatly to raise the character of the metropolitan university. The first to congratulate him on his appointment was Sir Isaac Newton, who afterwards wrote thus to the Lord Provost:—

"I am glad to understand that Mr. Maclaurin is in good repute among you for his skill in mathematics, for I think he deserves it very well; and to satisfy you that I do not flatter him, and also to encourage him to accept the place of assisting Mr. Gregory, in order to succeed him, I am ready, if you please to give me leave, to contribute £20 per annum towards a provision for him till Gregory's place becomes void, if I live so long, and I will pay it to his order in London."

This was, however, declined, his means proving sufficient; and in 1733 he married Anne, daughter of Walter Stewart, at that time Solicitor-General for Scotland. Maclaurin was the first who proposed the building of an astronomical observatory, and a convenient school for experiments in the University of Edinburgh; but he did not live to see either of these plans fulfilled. The Earl of Morton, on visiting his estates in Orkney and Shetland, in 1739, wished to settle the geography of those islands, which had hitherto been set down most erroneously in all maps, and applied to Maclaurin on the subject. He was unable at that time to undertake a journey to those remote isles; but he drew up a plan of what he thought necessary to be observed, furnished the proper instruments to survey the coasts and ascertain the meridian, and recommended Short, the celebrated optician, as a proper person to undertake the survey, through having a deep personal interest in geography. We are told, that "after carefully perusing all the accounts of voyages both in the South and North Seas, he was of opinion that the ocean was most probably to be found open from Greenland to the South Sea, by the North Pole; and when schemes for finding out such a passage were submitted to Parliament in 1744, he was consulted concerning them by several persons of rank and influence; but before he could furnish the memorials which he proposed to have sent, the premium was limited to the discovery of a North-west passage, and Mr. Maclaurin used to regret that the word *west* was inserted; for he thought a passage, if at all to be found, must lie not far from the Pole."

In 1745 he was very active in making plans for the defence of Edinburgh against the Highlanders, to whom its gates were peacefully opened, without a shot being fired; and as Prince Charles Edward, after his victory at Prestonpans, found himself in sufficient strength to punish, if he chose, those who had been active in the Hanoverian cause, he ordered all who had been volunteers for the defence of the city to subscribe a recantation of what they had done, under pain of being treated as traitors to James VII.

Maclaurin thus found himself in some peril, and fled to England before the last day of receiving the submissions; but not before he had found means to convey a good telescope and a supply of provisions into the Castle of Edinburgh, where some companies of the 47th Regiment, and other fugitives, were blocked up by the Highland clans. Dr. Herring, then Archbishop of York, hearing that Maclaurin had taken refuge in the north of England, invited him to reside with him while in that part of the country. On his journey southward he had a severe fall from his horse; and on his return home after the Highlanders marched into England, having been exposed to excessive cold

and tempestuous weather, he became seriously indisposed, and he was soon discovered to be suffering from dropsy in the abdomen. For the removal of this he was thrice tapped in vain, and it became evident, all medical skill having failed, that he would sink at last; but he remained calm and cheerful even to the end. When engaged in dictating to the amanuensis, whom he was now compelled to employ, that last part of the last chapter of his "Account of the Discoveries of Sir Isaac Newton," in which he proves the greatness and goodness of God, his voice was observed to falter, and his face grow pale. Dr. Munro was promptly in attendance; but the great mathematician breathed his last on the 14th of June, 1746, aged forty-eight years and four months. He lies interred in the Greyfriars Churchyard, where his son, John, Lord Dreghorn, erected the monument which still covers his remains.

The writings of Maclaurin were numerous, and his researches were deep. In 1740 he sent a paper to the Royal Academy of Sciences at Paris, on account of which he shared—as already lated in THE TECHNICAL EDUCATOR—the prize of the Academy with Bernouilli and Euler, for solving the problems relating to the motion of the tides, from the theory of gravity—a question which had been given out during the former year without receiving any solution. Among his many contributions to the *Philosophical Transactions* were papers "On the Construction and Measure of Curves;" "A New Method of describing all kinds of Curves;" "On Equations with Impossible Roots;" "An Account of the Annular Eclipse of the Sun at Edinburgh, 27th January, 1742-3;" "A Rule for finding the Meridional Parts of a Spheroid, with the same Exactness as of a Sphere," etc. etc. After his death, his "Treatise of Algebra," and his "Account of Sir Isaac Newton's Philosophical Discoveries," were published by his friends in 1748. Subjoined to the latter is a Latin tract, "De Linearum Geometricarum Proprietalibus Generalibus," on which his last hours were employed, and which was his farewell legacy to science.

CIVIL ENGINEERING.—XXV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

WE now pass on from the centering of an arch to the arch itself, our subject for the present being *masonry* bridges.

In arranging for the construction of a bridge, it is seldom that the engineer has a choice of ground; for the position of the bridge must be decided upon rather with a view to the requirements of traffic than to the suitability of the site. However, if the selection of the locality depend in any way upon the engineer, he will not fail carefully to examine the width of the river, the character of the banks, and, above all, the nature of the bottom. Whenever practicable, the position of the roadway should be laid directly across the stream, and a diagonal or *skew* bridge be thus avoided. The *height* of the roadway, and particularly the height of the water, either at extremes of tide if it be a tidal stream, or during floods if it be a fresh-water river, must be properly studied; and if more than one arch be required to span the stream, then the volume of water at extraordinary periods should be ascertained, as well as its rapidity, in order to guard against accident and obstruction in determining the size and shape of the piers. Some of the following observations are from a work on bridges, by M. Gauthey.

In no stream, whether tidal or otherwise, is the volume of water passing any given spot equal at all periods. The span and water-way of the bridge should therefore be wide enough to afford room for the superabundant quantity arising from floods, and it will be found that this quantity bears some proportion to the surface of the land which is drained off at that point of the river's course where the bridge is proposed to be erected; it is also very necessary to ascertain carefully the velocity with which the water, during a flood, travels past the spot. As the velocity of a stream varies at the surface and the bottom, both must be ascertained, and a mean obtained. If the velocity at the surface in inches per second = V, the velocity at the bottom may be represented by $(V + 1) - 2\sqrt{V}$, and the mean velocity by $(V + 0{\cdot}5) - \sqrt{V}$. The following table of velocities is calculated upon the basis of these formulæ, and is practically correct:—

Surface.	Bottom.	Mean.	Surface.	Bottom.	Mean.
4	1.0	2·5	52	38·5	45·2
8	3·3	5·6	56	42·0	49·0
12	6·0	9·0	60	45·5	52·7
16	9·0	12·5	64	49·0	56·5
20	12·0	16·0	68	52·5	60·2
24	15·0	19·5	72	56·0	64·0
28	18·4	23·2	76	59·5	67·7
32	21·6	26·8	80	63·1	71·5
36	25·0	30·5	84	66·6	75·3
40	28·3	34·1	88	70·2	79·1
44	31·7	37·8	92	73·7	82·8
48	35·1	41·5	100	81·0	90·5

Another formula for velocity is as follows:—

V = velocity at surface.
W = a constant number = 0·02707 metres.
U = the mean velocity.

$$U = (V - \tfrac{1}{2}W)^2 \div \tfrac{1}{4}W.$$

The above is by Dubuat, but M. Prony has adopted another and a more correct one:—

$$U = \frac{V\,(V + 2{\cdot}37187)}{V + 3{\cdot}15312};$$

or $U = \frac{4}{5}V$ may be considered sufficiently correct in practice. It is obvious, however, that particular cases will occur of extreme rapidity or peculiar formation of the bed of the river, in which no stated formula will hold good; and the engineer must in such cases—and indeed it would be safer to add in *all* cases—depend upon his own observations and experience rather than upon the observations of others.

In constructing a bridge, attention must be paid to the velocity with which the water will move under the arches at particular periods, and this velocity must not be allowed to be such as to cause the current to attack the bed of the river, and to injure the foundations of the piers and abutments. The nature of the bottom becomes an essential element in the case, as it may be either rocky or of sufficient tenacity to prevent the flow of the current from acting upon it; or it may be sandy and yielding, and in such a case it may be necessary to form an artificial bottom of piling and ground timber.

It is of course impossible to erect a pier in the bed of a river, or abutments projecting into the stream on either side, without causing more or less of an obstruction; and it becomes the duty of the engineer to determine as nearly as possible what amount of obstruction will result from the particular piers and abutments he purposes erecting. It is a problem which cannot be very accurately solved, but may be approximated:—

Let V = velocity of river in feet per second previous to the obstruction.
" A = sectional area of river in feet unobstructed.
" a = sectional area at the point of obstruction.
" R = rise of water in feet caused by the obstruction.

$$\text{Then } R = \left(\frac{V^2}{58{\cdot}6} + {\cdot}05\right)\left(\left(\frac{A}{a}\right)^2 - 1\right).$$

The following table of rise of water caused by obstruction will be found of use:—

Velocity in feet per second (V).	Rise in feet when amount of obstruction as compared with sectional area of river (A) =								
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$
1	·01	·03	·06	·11	·20	·35	·67	1·60	6·63
2	·02	·06	·12	·21	·35	·62	1·19	2·83	11·70
3	·04	·11	·21	·36	·61	1·06	2·05	4·88	20·15
4	·07	·18	·33	·57	·97	1·70	3·27	7·77	32·07
5	·11	·27	·51	·87	1·48	2·60	5·02	11·91	49·15
6	·15	·37	·59	1·18	1·99	3·48	6·71	15·93	65·75

It should be remembered that the velocities of a stream are in an inverse ratio to the areas of the corresponding sections.

The form given to the "starlings," or projecting ends of the piers of a bridge, exercises a considerable influence upon the manner in which the natural flow of a current is affected on meeting the obstruction. If we take unity to represent perfect obstruction at the pier, we may consider that produced by a starling whose form is semi-circular, or an acute angle = $\frac{1}{10}$; if the form be an obtuse angle, it will = $\frac{1}{10}$; if square, it will

$= \frac{3}{20}$; and if the arches are small, and their springing is under water, it will $= \frac{3}{15}$.

The forms of the arches of bridges are very various. They may, however, be grouped as follows:—Semi-circular; those formed by the intersection of two similar curves; those approaching more or less to an ellipse; and those consisting of a part of the circle. It is remarkable that in the most ancient bridges the semi-circular form has invariably been adopted. It forms the strongest arch which can be constructed; but in consequence of the height of the versed sine, which is equal to the radius, and therefore to half the span, it becomes necessary, in order to restrict the height of the roadway, to limit the span, and consequently to increase the number of arches, and correspondingly to diminish the water-way. Besides this objection, the springing of the arch requires to be very low, frequently below the water-line, and hence the obstruction is still further increased. All these objections are removed by the employment of a flat arch—that is, a segment of a large circle, or the intersection of two such segments. It was not, however, until the end of the seventeenth century that flat arches were introduced.

Whatever be the curve or curves given to the arch, it is desirable that the tangent at the summit should be horizontal; hence the Gothic arch, although beautiful in architecture, is not suitable for a bridge. The curve of an arch other than a semicircle, or arc of a circle, should consist of not less than three segments of circles.

When an arch is to consist of several segments of circles, it becomes necessary to obtain some means of determining the centres of those segments, so that some regularity shall exist in the gradual alteration of position of the tangents from the vertical at the springing to the horizontal at the crown. It is not intended to lay down any particular rule for this, neither is it necessary; we shall satisfy the requirements of the case by pointing out the course which has been pursued in certain cases.

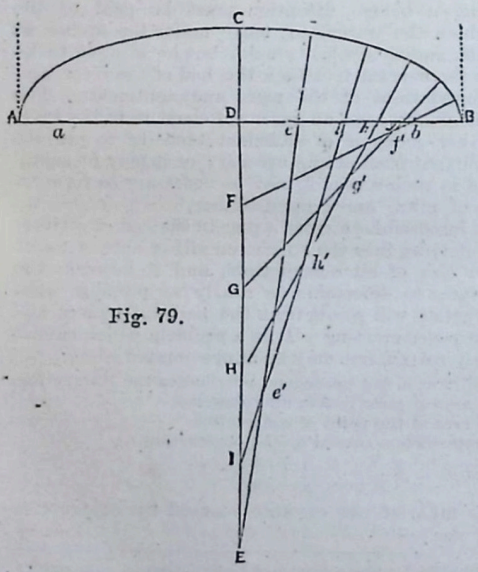


Fig. 79.

In the case of the bridge of Neuilly, commenced in 1768 by Perronet, a bridge justly admired for the beauty of its design, the arches are 128 feet span, and their springings on a level with low water. The form of the arches is elliptical, and the curves of their centres were struck as follows:—

Let A B (Fig. 79) represent the chord line or greater diameter of the intended arch, and *a b* the centres of the curves at the springing, ensuring the verticality of the tangents at this point. Let C be the height of the crown of the arch, and prolong C D to any point E, making D E a multiple of D *b* (in the case of the bridge at Neuilly this was triple), and divide D *b*, D E into the same number of parts (in this case five), making the parts on D E equal, and those on D *b* in the proportion to each other of 1, 2, 3, 4, and 5, and join the points of division by the lines F *b*, G *g*, H *h*, I *i*, E *e*; then the respective points of intersection of those lines, E, *e'*, *h'*, *g'*, and *f'*, will be the centres of the different arcs which compose the arch, each arc being bounded by the prolongation of the lines F *b*, G *g*, etc. In adopting this plan for the formation of the curve, it will be seen that we started with fixing the points *a* and *b* arbitrarily upon the line A B, and that all the other steps are dependent upon the position of these two points. In practice, however, it is usual to decide beforehand what shall be the relative values of A B and C D; therefore, as certain points in the curve have become fixed, it will be found necessary somewhat to modify the respective segments so as to ensure C D remaining at the required height.

An ellipse may be constructed by ordinates, and the lengths of the ordinates be calculated by the following formula:—

Let R (Fig. 80) = semi-transverse axis; S = semi-conjugate axis; X = length of any ordinate; Y = distance of ordinate from centre.

$$\text{Then } X = \sqrt{S^2 - \left(\frac{S\,Y}{R}\right)^2}.$$

As the lengths of the ordinate in an ellipse bear always a definite proportion to the length of the semi-conjugate axis, it is easy to assign a value to this proportion taken in certain fixed positions along the semi-transverse axis, which in fact becomes half the span of the bridge whose arch has the elliptical curve. Supposing, then, that the semi-transverse axis be divided into ten equal parts, the length of the ordinates at these points will be as follows, the length of the semi-conjugate axis being taken as unity. Commencing from the centres, the values would be, the semi-conjugate axis being 1·0—

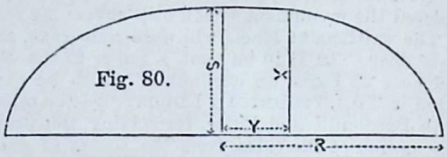


Fig. 80.

No. 2 = ·9949.	No. 5 = ·9165.	No. 8 = ·7141.
„ 3 = ·9797.	„ 6 = ·866.	„ 9 = ·6.
„ 4 = ·9639.	„ 7 = ·8.	„ 10 = ·4358.

We have been careful to draw attention to the form of the curves of arches, as so much of the beauty of a bridge depends upon the character of the arch.

As we have no room to consider the mode of construction of masonry bridges, we will conclude this chapter with one or two extracts which show the extreme necessity that exists for providing a sufficient water-way.

In 1822 floods produced by excessive rain occurred in Scotland. Rivers assuming an aggregate length of upwards of 500 miles were flooded, and the whole of their courses were marked by the destruction of bridges and other impediments. Sir T. D. Lauder, in his account of this flood, records the destruction of thirty-eight bridges. The bridge over the Dee at Ballater consisted of five arches, with a total water-way of 260 feet. The bed of the river on which the piers rested was composed for the most part of granite, of which material the bridge itself was built; but after standing uninjured for twenty years, the different parts were swept away in succession by this flood, and at last the whole mass disappeared in the bed of the river.

In 1827 heavy rain occurred on the Cheviot Hills, and a small stream called the College was so swollen thereby that a bridge in course of construction was carried away, some of the voussoirs of which weighed from 10 to 15 cwt. It may be argued that these were exceptional cases; but as they are known to occur, it becomes only an act of prudence to prepare against every probable eventuality.

The friction of running water against the bottom and sides of the bed of a stream is another source of danger to bridges, which, as we have already pointed out, can best be met by piling. The fact that the surface of a stream moves more rapidly than the bottom, and the centre of the surface than those portions near the banks, is due wholly to the retardation caused by friction against the sides; and it has been ascertained by observation that a velocity in the stream of only three inches per second against the bottom is sufficient to tear up and remove fine clay, whereas six inches per second will remove fine sand, twelve inches per second fine gravel, and three feet per second stones as large as an egg. It is no cause of wonder, then, that where insufficient precautions are adopted with respect both to the water-way and the channel of a bridge, damage will frequently arise. The whole channel of the St. Lawrence, from the Niagara Falls to the town of Queenstown, a distance of seven miles, presents an instance on a grand scale of the power of running water to cut away the bed along which it flows. In France many valleys are to be found where the channels of rivers have been barred by currents of solid lava, but through which the streams have re-cut a passage for themselves, in some instances to great depths.

HOROLOGY.—V.

By I. Hermann, late Teacher of Technical Science to the British Horological Institute.

THE DUPLEX ESCAPEMENT.

We now proceed to a description of the duplex escapement. In the first escapement described we have the pallets shutting off, so to speak, the rotary or centrifugal force of the escape-wheel for regular intervals, during which the balance moves as free of the escapement as if it was a mile away from it; and in the chronometer we have the detent doing the same office. In both these escapements there is this intermediate mechanism, by which the balance is kept totally detached from the rest of the mechanism of the watch during a definite angle of its vibration.

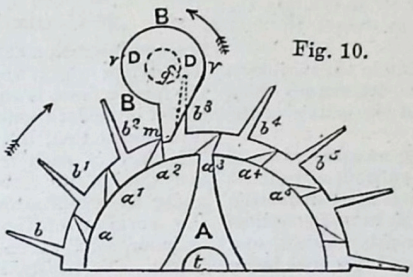


Fig. 10.

A mere glance at Fig. 10—being the plane of the duplex—will at once discover the absence of any such intermediate or third piece in addition to the escape-wheel and balance; and hence the centrifugal force of the escape-wheel, which is equal during motion or repose, is acting and pressing against a section of the balance during all its motion over and above the arc of impulse, in the same ratio as the lever escape-wheel presses against the locking, or the chronometer wheel against the pallet of the detent; and hence the balance stands in the same relation to the escape-wheel as the pallet and detent to the respective wheels of the former escapement, and for this principle is undetached.

Proceeding to definitions of our illustration, we have in A a section of the escape-wheel, having fifteen horizontal teeth, represented by b, b^1, b^2, b^3, and so on, and fifteen vertical teeth, delineated at a, a^1, a^2, a^3, and so on. Its appliance to the escape-pinion is by the concentric hole t, in the same manner as described by the other escape-wheels. B B is a piece of steel of the given shape, fixed to the balance in the manner of lever or chronometer roller, and concentric with its boss, v v, and is called the duplex pallet.

Below the pallet is a jewelled roller, represented by the dotted circle D D, fixed also concentric to the balance, and called the ruby-roller. It has a notch at g, of minimum width of the thickness of an escape-tooth. In the elevation of this escapement the horizontal teeth, b, b^1, b^2, etc., are in plane or level with the ruby-roller. Above these teeth, which are on a level with the rim of the wheel, is the pallet B B, sufficient clearance being left to prevent its contact with the rim of the escape-wheel, or teeth b, b^1. Projecting at right angles to the rim, and above the pallet B B, are the vertical teeth a, a^1, a^2, etc. The positions of balance and escape-wheel are determined by jewel-holes, in the same way as the lever or chronometer escapement.

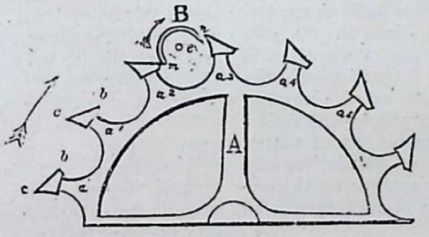


Fig. 11.

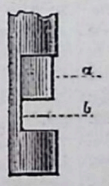


Fig. 12.

The action is as follows:—The escape-wheel, moving in the direction as indicated by the arrow, is in contact with face, m, of pallet, B B, by its vertical tooth a^2. The condition of this contact is again that of two intersecting arcs; and hence when by the rotation of wheel and pallet the point of intersection is reached, tooth a^2 becomes disengaged from the pallet-face m. The escape-wheel now moving freely, brings tooth b^2 in contact with the circumference of the ruby-roller, D D, by which it is arrested during the completion of one and part of another vibration of the balance. The minimum width of the roller-notch g being equal to the thickness of a tooth b, plus its clearance, when on the return motion of the balance this notch, g, in the roller, D D, repasses the periphery of the escape-wheel (the contact of wheel and this roller being also proportioned to two intersecting arcs), a drop or forward motion of the escape-wheel takes place, equal in its angular measure to the span of the notch g, which brings the tooth b^2 in contact with the side of the notch that faces the direction of the escape-wheel. This motion gives a decided check to the balance. The radius of the roller being small, and the centrifugal force of the wheel inversely proportioned to the radius of its teeth, it is not sufficient to stop the balance; but the force of the wheel is overcome by the balance-momentum, and forced or propelled back until the end of the side of the notch in contact has passed the periphery of the escape-wheel, and so the point of tooth b^2 is again resting on the roller circumference, and the vibration proceeds.

The contact of the escape-wheel and the roller D D being proportional to two intersecting arcs, when therefore, on the return motion of the balance, the notch enters the periphery of the escape-wheel, the tooth b^2, without any drop, passes off the circumference on to the side of the notch last in contact, and moves simultaneously with it, until the point of intersection is again passed, and tooth b^2 becomes disengaged from the roller-notch g. At this stage the end of pallet B B has entered the periphery of the vertical tooth a, by about one degree measured from its centre. The escape-wheel being free to move, a slight drop takes place, which brings tooth a^1 in contact with the face m of pallet B B, as illustrated in our diagram, when the impulse-action first described re-commences, and so on to the repetition of this action, as long as the watch is wound up.

It will be noticed that we have here four relative radii, namely, those of teeth a and b, and of roller and pallet. It is the ratio of the pallet-radius, B B, and vertical tooth, a, that determines the impulse-angle, and *vice versâ*. There is no definite angle adopted in its manufacture or construction: the angle, indeed, varies from 30° to 40°, and even 45°.

The angular impulse-motion of the escape-wheel is considerably less than the measure of two teeth, which is equal to the chord of the intersecting arcs of roller D D and tooth b; plus the drop off the pallet-face, m, on to the roller, and off the latter on to the former.

One of the chief conditions of error is the pressure of the teeth b, b^1, etc., against the roller during the vibrations, and this pressure is again proportioned to the roller-radius. Hence it is an advantage to make this radius at a minimum, thereby reducing the factor or coefficient of resistance; this minimum is, however, limited by two conditions. The roller, D D, is connected to the staff, which passes through a small hole in its centre, and hence the staff will require to be thinned in proportion to the diameter of the roller; and considering that this is the axle of the balance, certain stability must remain, and thus a limit is given to the roller-diameter. In addition to this limit set by the build of the escapement, there is another by the mechanism of this contact.

The balance-arc from the point of entry of tooth b into the notch g, to the point of its exit, depends upon the relative distance in plane of the two centres; and as in this escapement, the same as in the chronometer, impulse is only given once every two vibrations, and the escape-wheel is in repose until the notch g passes the periphery of the teeth b, b^1, etc., and cannot give impulse till then, it follows that in proportion to the intersection so is the angular measure from the roller-centre, and so has the balance to describe an arc from its repose before it can receive impulse-contact. The greater this angle the more the watch with a duplex escapement is inclined to set; and, inversely, the smaller this angle the less this inherent error asserts itself.

But as the measurement of the roller-resistance to the escape-wheel is the depth of the two intersecting arcs, and this depth diminishes by a diminished roller-angle of the intersections, we get a very delicate wheel, and roller-contact by a smaller roller,

and hence multiply the chance of error in this direction in two-fold ratio.

On the other hand, by making the roller-diameter too large we increase the co-efficient of resistance, and with it, and in proportion to it, diminish the impulse-angle of the escape-wheel. As in circles of different radii, the arcs that subtend them vary as their radii, so we have in a larger roller a longer chord of the intersection by roller-contact, and hence a greater angular motion of the escape-wheel during the roller engagement. The angle of two teeth of a fifteen-tooth wheel is 24°, and one degree of drop on to the pallet and one off leave 22°, from which has further to be deducted the angle of its motion during roller-contact, and hence the larger the diameter of the latter the less the angular motion left to the escape-wheel to give impulse.

These are, therefore, the two points of limit to the minimum and maximum roller-diameter, and experience determines them between one-third and one-fourth the space of two points of the horizontal arcs.

When we, therefore, wish to determine the relative ratio of the radii of the vertical teeth a, a^1, etc., and pallet B B, we must ascertain the impulse-angle of wheel that is left after deducting its three foregoing motions. This would lead us to mathematical formulæ not in keeping with our papers on this subject, and hence we will only trace out a few points to be observed as being of most importance.

The arc of wheel and roller intersection is completed before the impulse-contact of wheel and pallet commences, and as the termination of the roller-contact is at the point the impulse-contact commences, it follows that the greater the chord of the arc, and with it the angular measure, the further the balance has to move before the points of teeth b, b^1, etc., can enter the roller-notch, the point of this entry being the opposite intersection of the roller-contact.

The impulse-arc of the escape-wheel is measured from the end of either of the vertical teeth a, a^1, etc., in a direction opposite to its direction of rotation. That is to say, when the wheel is at repose against the ruby-roller, and a line is then drawn between the two centres, the distance from this line to the next tooth, measured in the direction the wheel is moving, is half the angular measure of its impulse, plus the drop; and hence the distance from this line to the next tooth in the opposite direction is half the impulse-angle plus the roller-angle of contact, plus the drop. It follows from this that the position of the vertical tooth leaving the impulse-contact is determined by the roller-arc of intersection, and consequently also the length of pallet. By making this arc of roller-contact at a minimum, we are thereby enabled to reduce the tendency for setting on the one hand, and increase the impulse-angle of wheel and length of pallet on the other.

It is desirable to have a wide notch in the ruby-roller, rather than a narrow one, because the angular motion of the balance required in excess of the position of the pallet in the periphery of the escape-wheel is such as to allow the long or star teeth, b, to enter the notch. By examining our illustration, it will be easily observed that with a wider notch this effect would be obtained with a shorter balance-motion, and is therefore again of important advantage as regards setting.

This escapement is of the most delicate nature, scarcely less delicate, indeed, than the chronometer. It will easily be conceived that if there is any or the least difference in the lengths of the star-teeth b, b^1, etc., the variation in the balance-angle of roller-contact between the shortest and longest tooth is very great, and hence there is a corresponding variation in the balance-arc of impulse; because by the longer arc of roller-contact we get an excess of drop on to the face, m, of the pallet, or inversely, by a shorter tooth the roller-contact ceases before the pallet enters the periphery of the wheel, and so loses impulse-contact entirely. The careful adjustment of the equality of the lengths of those teeth is therefore of great importance; or, in other words, the escape-wheel requires to be most accurate in its truth. In consequence of the delicacy of this roller-contact the balance-pivots require most careful adjustment in the jewel-holes, as every side-movement of the pivots in bad-fitting holes produces errors in consequence.

This escapement, which although simple, yet requires great skill in making, is expensive for the manufacturer, and, by reason of its delicacy, is also costly to the wearer of a duplex watch; hence it is fast going out of date as a popular portable timekeeper, and is in this sense succumbing to the more favoured lever escapement. And being undetached, it falls short of the properties required in the escapement of a more perfect watch, and hence it is not only manufactured at a very small rate, but is often taken away to have its place supplied by the lever. This is, however, more often done than needful, for when carefully attended to it gives very excellent results, and its deficiency is more often than it ought to be the result of ignorant and unskilled labour, and so has to bear the contempt that justly belongs to the man who passes under the popular term watchmaker, but who is in this case misnamed.

THE HORIZONTAL ESCAPEMENT.

Our illustration (Fig. 11), shows the plan of this escapement. The escape-wheel, which is applied to the pinion in the manner of the former ones, is shown at A, and its teeth at a, a^1, a^2, etc., of which in modern watches there are mostly fifteen. By virtue of its construction, the escape-wheel forms the principal section. The face of each tooth, b c, forms an inclined plane with the direction of its rotary motion, which, being movable, comes under the modification of a wedge. B is the plan, and Fig. 12 the elevation of the cylinder. Its form is that of a hollow cylinder, solid at each end, into which two pivoted plugs are driven. Vertically, its central part has two-fifths of its circumference cut away, as shown in B and a (Fig. 12); and at b (Fig. 12) it is further reduced, leaving only as much of the tube as to keep its upper and lower parts firmly connected. The parts c b of the escape-teeth are elevated above the rim, and connected with it by a foot or stem. The action of its mechanism is as follows:—The wheel is moving in the direction indicated by the arrow. The point of tooth a^2, answering to b of tooth a^1, is in contact with the circumference of the cylinder B, which is rotating about its centre e, and in the direction indicated by the adjacent arrow. The escape-wheel is in repose until the section m of the cylinder B has passed the circle drawn through the point b, when the wheel moves on with a constant velocity, until section m has passed the periphery of the wheel, when a short drop takes place on to the inside of the cylinder, such drop being no more than is necessary to give sufficient clearance to the tooth inside the cylinder, and the cylinder between the teeth. On the return motion of the cylinder, we have a repetition of the action described on section n of cylinder B, and so on alternately.

This alternate contact of cylinder section m n, and the inclined plane, b c, of the escape-teeth being the impulse, it will readily be seen that the measure of the impulse-arc of the cylinder depends upon the angle of b c with the direction of the wheel. In detached escapements it is desirable to reduce the arc of impulse to a minimum, but here it is the reverse; because in the former the arc in excess of impulse is free, but in the point b it is exerting a constant pressure against the surface or the hollow of the cylinder; hence the balance vibrates freer during the interval of impulse than during the repose of the wheel. Much might be added on the conditions underlying this fact, as well as on the curve that the incline b c sometimes takes, but such is beyond the limit of these papers.

No definite ratio exists between the radii of the cylinder and the wheel. If the circumference of the cylinder were a line according to Euclidean definitions—that is, without breadth—then its diameter would be half the measure of two teeth. It follows, therefore, that the thickness of the cylinder-tube determines the ratio, and the more solid it is, the smaller the ratio between tooth and space.

We must refrain from entering on these conditions and their effect, and will only add that in practice a cylinder should be selected that gives a good clearance for the tooth inside, and on each side. The relative positions in plane for wheel and cylinder should be as distant as possible in portable escapements to prevent setting, the condition of limit being the point of contact after drop, such being firmly on to the circumference, but no more than safe.

The vertical position of the teeth is at a (Fig. 12), and that of the rim at b. In this escapement it is necessary to limit the motion of the balance to one half turn, measured from its repose, which is technically called "banking," being effected by a pin inserted in the balance and another at an angle of 180°, thereby permitting the balance to vibrate half a circle.

WOOL: ITS INDUSTRIAL APPLICATIONS.

By A. Gallety, Curator, Industrial Museum, Edinburgh.

VII.—MANUFACTURE OF CARPETS.

First in order, as regards the length of time they have been in use, as well as on account of their simplicity, beauty, and intrinsic value, we require to take the carpets of India, Persia, and Turkey. Though the high artistic taste displayed in these is not equally good for all three countries, yet they have a great deal in common, and are all made on the same principle, which is an exceedingly simple one. The loom is commonly of the most primitive kind, consisting of two posts, fitted, at a suitable distance apart, with a beam or roller at the top and another about two feet from the ground. Between the two beams hang, vertically, the warp threads; and each coloured tie or tuft of wool passes across two of these and has the ends drawn up between them, so as to form a kind of knot, like that shown in Fig. 36, or of some equally simple kind. When a row of these ties is completed, a "shed" is formed in the warp by means of the "heddles," and a weft thread thrown across from right to left and returned, so as to bind the tufts firmly into the fabric, the weft being beat close up by an instrument called a "lay." Another row of coloured tufts is then knotted or twisted in, another weft thrown, and so, with the aid of a drawing, and sometimes without it, the slow and tedious work goes on. The carpet is wound up bit by bit, as it is woven, on the lower beam. It is obvious that by this plan there is practically no limit either to the kind of design, the number of colours, or the size of carpet which may be adopted. Some carpets are, however, made in India on horizontal, and perhaps more primitive, looms, in which there are no treadles to raise and lower the warp strings. In these the weft is not thrown across with a shuttle, but is passed through the warp by several workmen, the narrowest piece requiring two, and a very wide one eight or ten to conduct the weaving.

Such are the rude and simple methods by which what are by far the most beautiful and durable carpets in the world are made; but the process is so slow and laborious that objects so woven must needs be very costly. Occasionally an Indian rug or small carpet will bring as much as three hundred pounds, and one carpet made in Cashmere of fine goat's wool was sold in Paris in 1867 for more than double that sum. So high is the artistic merit of these fabrics that European manufacturers are considered to have improved their designs within the last twenty years far more than at any former period, chiefly through introducing something of the spirit and appropriateness of Eastern patterns into their productions. Dr. Forbes Watson gives a curious illustration of what is likely to result from the contrary practice of getting Indian workmen to imitate European designs. He says: "A striking instance of this was afforded by a large carpet made in one of our Indian gaols of Berlin wool, and sent to the International Exhibition of 1862. The pattern consisted of big roses and other flowers grotesquely distorted, and was, we believe, considered quite a *chef d'œuvre* by the gentleman who directed and superintended its execution. At the termination of the exhibition it sold for less than the original cost of the wool."

Considerable numbers of Indian rugs and carpets are now sent to Europe, but the commerce in Turkey carpets is much more extensive. These are chiefly made at Oujak, in the neighbourhood of Aidin, and exported from Smyrna. Similar carpets are made in Algeria, Tunis, Russia, and Holland. The English Axminster carpet is also a costly hand-made fabric of the same nature, the manufacture of which is, or not long ago was, carried on in a single establishment at Wilton, whither this limited branch of the carpet trade was transferred some thirty or forty years ago. Aubusson carpets, so long and so highly esteemed in France, are likewise hand-made; but the peculiar nature of the design, as well as the fine texture of these fabrics, render them more of the character of tapestry. Without saying more about these high-class goods, we now proceed to give an outline of the manufacture of the more common but still beautiful kinds, and shall begin with the

Kidderminster or Scotch Carpet.—This is the oldest kind of our ordinary carpets, and although no longer manufactured at Kidderminster is still largely made in Durham and Yorkshire; and in Scotland at Kilmarnock, Bannockburn, Aberdeen, and a number of other places. The "Scotch" differs from all other descriptions of carpeting in having, like a damask of more than one colour, a similar pattern on both sides so far as outline is concerned, but with the colours reversed. Thus if on one side a leaf appears red on a green ground, on the other it will appear green on a red ground. A real Scotch carpet is all wool, but fabrics similar in appearance are made with cotton warps and worsted wefts, in which case they are called "unions." In thickness it consists either of two or of three layers of cloth, and according to which it is named a two or a three-ply carpet. The so far separate layers are united at many different points, because the yarns, according as their colour suits any particular section of the pattern, sometimes form part of the upper, sometimes of the lower web; or if it is a three-ply, each thread is partly woven into all three layers. Both two and three-ply carpets may be wrought with only one colour of weft, in which case the figures in the pattern are formed by the warp threads. When this is done, the warp yarns are made much thicker than those for the weft, and for this reason: if the colours used are only three—say black, red, and green—and black is chosen for the weft, then, as this has to cross every flower or leaf of red and green, it must tone down their brightness; at the same time it intensifies the black spaces, just as a red weft would intensify the red spaces. Plainly, therefore, the thinner the weft thread, compatible with strength, the better. However, all the best carpets are made with as many colours in the weft as there are in the warp, but, of course, at some additional expense. A Scotch three-ply, if made of thoroughly good material, though wanting the rich appearance of a "Brussels," is one of the most durable carpets made, besides possessing the advantage of having two sides or faces, one of which can be made to look very different from the other, although both have the pattern the same in outline. Jacquard looms, or rather looms fitted up with Jacquard apparatus, are now almost entirely used in weaving Scotch as well as Brussels and Wilton carpets.

Venetian Carpeting, so much used for stairs, resembles Scotch in appearance, but being usually made with some simple pattern, and this being formed entirely by the warp threads, it can be woven on common looms. The weft is concealed, and is of linen or hemp. A similar but coarser kind called *Dutch* carpeting is, however, made with worsted weft.

Brussels Carpet.—Very much as silk velvet is richer looking than plainly woven silk does the so-called "Brussels" carpet excel in appearance the Scotch or Kidderminster. This variety of carpet appears to have been introduced into England nearly a century ago, and is more largely made than any other kind of our better class carpets. As some other varieties about to be noticed more or less resemble "Brussels," we shall explain its structure fully; and as it will help to make this, as well as the nature of the weaving in the others, more clear by comparing them with plainer textures, we give a few diagrams illustrating these. Figs. 37 and 38 show plain, and Figs. 39 and 40 twilled weaving. Fig. 41, again, shows the structure of velvet. Brussels carpet is not unlike velvet in its character, as will be seen by examining Fig. 42, which is a face view, and Fig. 43, which is a section across the weft of a fragment, both being double the actual size. In Fig. 42 the portion marked A represents the finished pattern, which, let it be understood, is entirely formed of the *woollen* warp. The other portion, B, shows the *flax* warp and weft threads only; but we may take the tinted interspaces in the latter to be made up of the woollen warp threads stretched quite straight, in which case it would represent the appearance of the back of the carpet at all times and of the face too, if we choose to pull down the loops seen in Fig. 43 which rise at intervals, according to their colour, to form the pattern. The upper and under rows of weft threads (*w t*) thus enclose between them a certain number of coloured woollen warp threads, and the whole fabric is bound together by the double lines of linen warp marked *l w* in the figures. In weaving Brussels carpet the coloured warps are arranged in bobbins set in frames at the back of the loom. There is usually a separate frame for all the bobbins of one colour, and according to the number of colours in one line—say the line C D—the fabric is styled a two, a three, or a five-frame carpet. The peculiar and most complicated-looking loom on which these are woven has a Jacquard mounting, which raises at one movement all the proper warp strings, that is, those, and those only, which suit that section of the pattern across the breadth of the web. A wire is now

inserted to form the loop, which is then bound in by linen weft, for which, by suitable "harness," there is the necessary "shed" made in the linen warp as well. Another set of coloured warp strings are next raised, another wire inserted, another tie of linen weft and warp made, and so on. Only a limited number of wires are required, and there is a motion for withdrawing the one farthest back and re-inserting it in front as the weaving proceeds. The "wiring" process has been recently simplified by the application of magnetism. Three of these wires are shown in position on the left of Fig. 43. It should be clearly understood that whenever there are, say, five colours in one line, all the five warp threads are present throughout its length, although only one comes to the surface in the form of a loop or loops at a time. Supposing the worsted warp to be of the same size and quality in both cases, a five-frame carpet would therefore have more threads packed into a given space than a three-frame one, and consequently it has so much more wool in it. A good figured Brussels, 27 inches wide, requires some 1,300 bobbins of coloured warp threads.

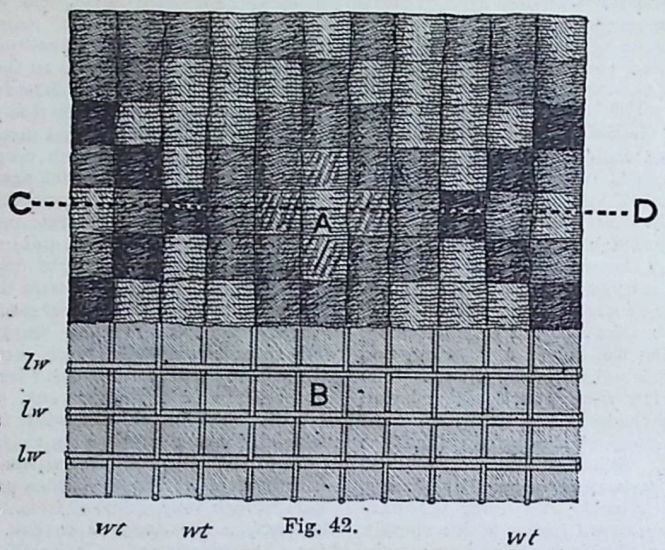


Fig. 42.

Velvet-pile or Wilton Carpet.—The structure of this carpet is almost the same as a Brussels, the chief difference being that in the "pile" the loops are cut, so that it still more closely resembles velvet. In order to facilitate the cutting of the loops, the wires used in weaving pile fabrics have a groove on their upper edge, along which a knife is drawn. As in the case of velvet itself, this kind of carpeting requires to be cut on a spiral or other cutting-machine, so as to reduce the surface to a uniform level. The upper weft threads in a pile carpet are usually twice as many as in a Brussels, in order to hold in the cut tufts very tightly, as will be seen by comparing Fig. 44 with Fig. 43. Wilton carpets, being generally made of finer yarn, besides being altogether a more expensive manufacture than Brussels, sell at a correspondingly higher price. The chief seat of both Brussels and velvet pile carpets in Great Britain is Kidderminster, where there are at present in operation about 900 power-looms, the trade there employing in all not less than 3,000 work-people. A few hand-looms are also still at work in the town.

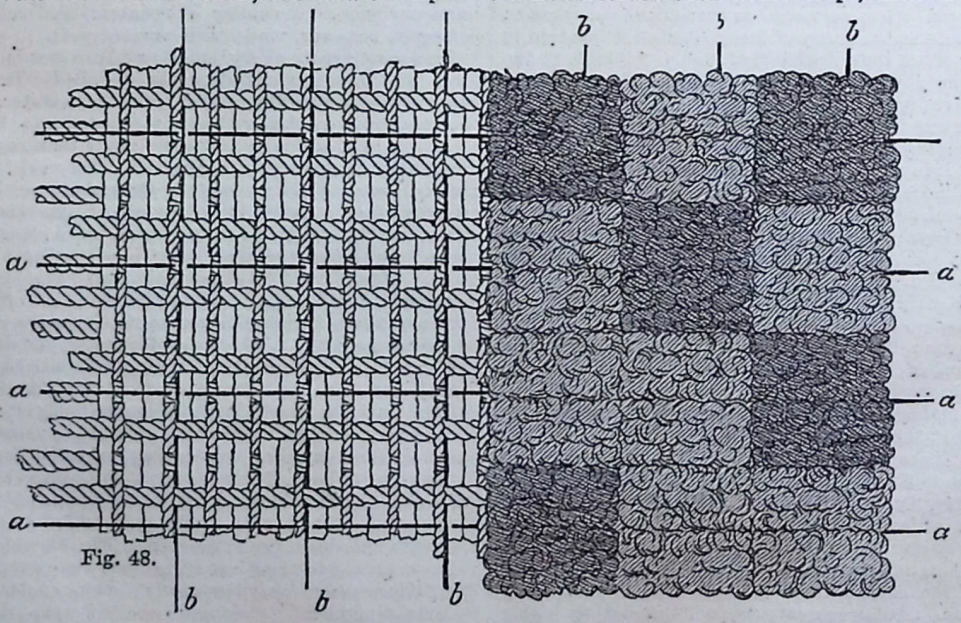


Fig. 48.

Tapestry, or Printed Warp Carpet.—In the year 1832, Mr. Richard Whytock, of Edinburgh, patented a method of imitating Brussels carpet with parti-coloured warp yarns, which has been of greater service to the carpet industry of the country than any other improvement of modern times. The invention is one of great ingenuity and simplicity, and so entirely original that the patent, notwithstanding its brilliant success, was allowed to run its course without any of those legal contentions which so commonly attend profitable patents. It was even renewed for five years after the expiry of the usual term of fourteen years. The structure of this fabric closely resembles that of a Brussels carpet, as the two figures 43 and 45 will show, Fig. 45 being the tapestry carpet. Both have their pattern entirely produced by the warp, but on Whytock's plan a single warp thread does what it takes a number to do in a Brussels, and this is effected in the following way:—To save making another figure we shall now suppose that Fig. 42 represents a fragment of Whytock's tapestry carpet, and that along the line C D there are five colours, then the single warp thread which travels along this line is printed red for a certain length, green for another, it may be a greater or a smaller length, and so on with orange, blue, and black, taking these to be the five colours. In this way one thread will do lengthwise, however many colours are required, but no two threads with the coloured spaces exactly alike go together, because in the case of a red flower, for example, where a thread passes through the centre, it must have a longer portion coloured red than one passing through near the edge. In such a case, of course, every thread between these two must have this particular coloured space of a different length. Since the parti-coloured threads are formed into loops, whatever tinted portion of a thread comes in for the breadth of a flower or other figure, it must be four times as long in the yarn as it will afterwards appear in the web. Much care and correctness are therefore required in calculating the various sizes of these coloured spaces, and great nicety is likewise necessary in adjusting the pattern in the warp, because such carpets are woven on simple looms with none of the usual arrangements for figure-weaving. Mr. Whytock's first plan of colouring the yarns was by winding them on a large hollow drum, and printing each colour with a long block; subsequently small rollers, each working in its own colour box, and so arranged as to work across the drum, have been used to print the dyes. When the printing is completed, the drum appears covered with stripes or bars of different widths and tints, and the yarns are afterwards steamed to fix the colours. Mr. A. Whytock, in a paper read before the Society of Arts in 1856, thus speaks of his relative's invention:—"Not only is the Jacquard superseded, and the large frames done away with, but it is

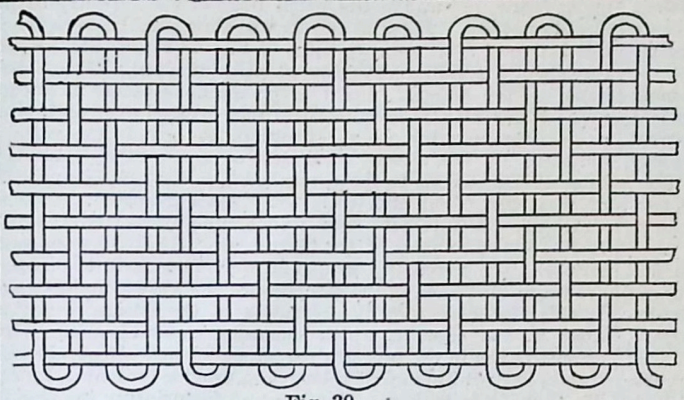


Fig. 39.

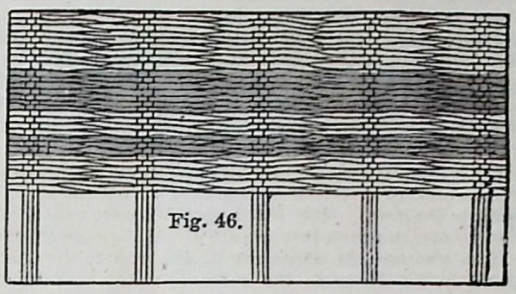


Fig. 46.

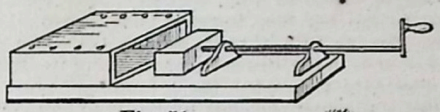


Fig. 51.

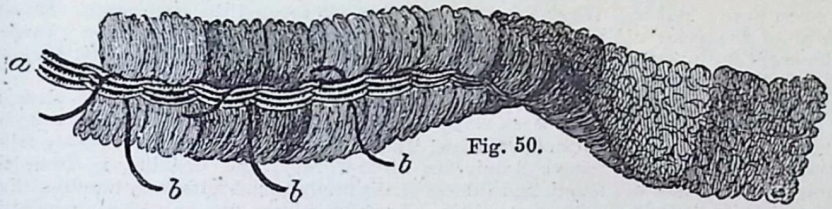


Fig. 50.

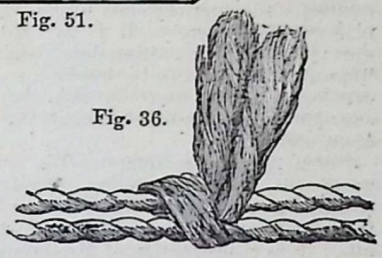
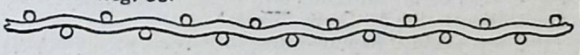


Fig. 36.

Fig. 40.

Fig. 38.



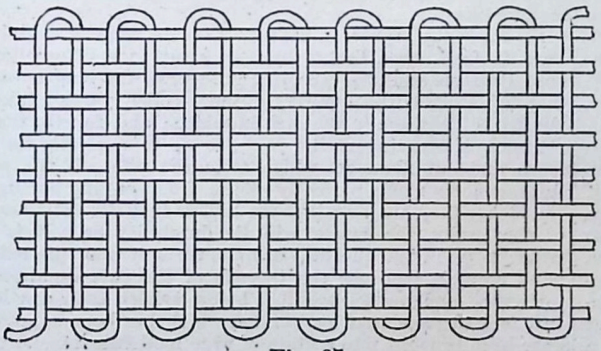


Fig. 37.

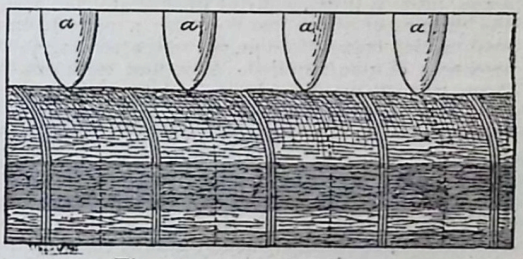


Fig. 47.

Fig. 45.

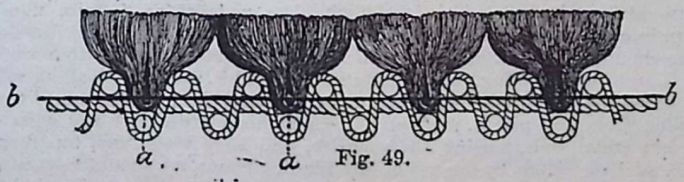


Fig. 49.

Fig. 52.

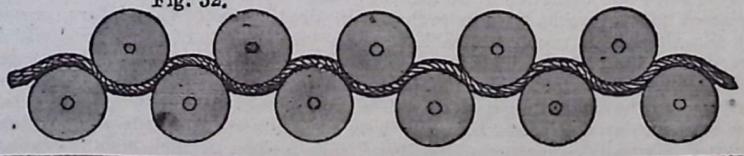


Fig. 44.

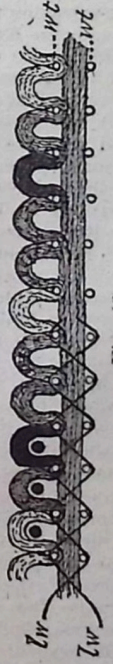


Fig. 43.

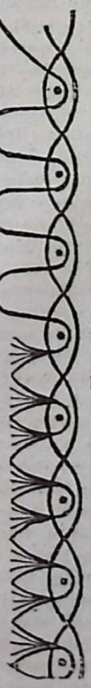


Fig. 41.

possible to place three looms to be occupied by this new fabric into the space which one Brussels loom requires. One beam is substituted for 1,300 little beams or bobbins, and a better cover is made with 780 threads than with 2,600."

Whytock's patent has been, and still is, worked on a most extensive scale in Messrs. Crossley's great establishment at Halifax, the firm having from time to time introduced great improvements in the method of printing the yarn. Probably this kind of carpet is much more largely made than any other, as it has as good an appearance as a Brussels at about two-thirds the price. But if the question were asked, is the one as economical as the other, we are afraid the answer must be "no." If we compare the structure of the two fabrics, we shall find that in the Brussels the coloured wools make up the bulk of the carpet, while in the "tapestry" the wool, although disposed in the best way to resist wear, is yet all on the surface, coarse flax or jute threads taking the place of the hidden worsted ones in the Brussels carpet. As jute, flax, or hemp has less elasticity than wool, the "tapestry" must so far fail in comfort, and experience has proved it to be somewhat wanting in durability wherever it is exposed to much wear. But as even jute carpets, costing less than a third of the price of "tapestry," are not to be despised, so, if the beautiful tapestry carpets are not all we could wish, they still suit many purposes abundantly well, and their manufacture is one of the successes of our day.

Patent Axminster Carpet.—We come now to another improvement in carpet-making, equally ingenious, and perhaps equally successful, with Mr. Whytock's, except that the fact of its being a much more costly fabric must necessarily limit its sale. It is the invention of Mr. James Templeton, of Glasgow, and is thus described in his own words in an interesting communication to Sir M. Digby Wyatt:—

"I was a shawl manufacturer in Paisley, and, amongst other goods, made a great many of what are termed chenille shawls, the process of which was to weave a pattern on a warp, the warp having been spaced on the reed according to the depth or thickness of pile required. This first cloth was then cut between the spaces into shreds, and then these shreds, having been twisted into a spiral form, were woven on to another warp, marks for the weaver's guidance having been woven in the first weaving to enable him to place the shreds so as to bring out the complete pattern in the second weaving. The idea occurred to us (one of my weavers and myself) that, if cloth could be so woven, as when cut into shreds and not twisted to form chenille, but left free, so that the two cut edges of the shred might collapse and form a pile, or fur, as we term it, it would, when re-woven on to another warp or surface, produce a velvet, a pile, or an Axminster surface. This was accomplished by a certain mode of gauze-weaving, and a patent was taken out for it. In protecting this patent, in 1847, on a trial in which we got a verdict on all the issues, the judge (the late Lord Robertson), when re-examining a witness, smartly remarked, after he had seen the difference between our products and those of our opponents (our opponents wished to make out that ours was only the old chenille process), 'Oh! I see, this new fabric (or shred) has its backbone where it ought to be, and the chenille has its backbone in its middle.'"

The first part of Mr. Templeton's process, and what really constitutes the gist of his original patent, dated 1839, consists in weaving on a separate loom a single or parti-coloured chenille of such a peculiar kind that, when cut up into strips, the lateral fibres of both cut edges are all brought up in close compact with each other. Fig. 46 shows a piece of the chenille uncut, and Fig. 47 shows the manner of cutting it, *a*, *a*, *a*, *a* being the cutting-blades. These sever the different rows as the web passes over a cylinder. Figs. 46 and 47 are taken from the reports of the Exhibition of 1871, and are on a less scale than the three following ones. A face-view of part of four rows of this chenille, or fur, or pile, as it is variously called, is given in the lower portion of Fig. 48. A cross-section of these four is seen in Fig. 49, and another view of a detached piece, showing part of the "back-bone," is given in Fig. 50. These figures, as in the case of the Brussels carpet, are double the actual size of the parts they represent of an ordinary patent Axminster, but, of course, the length of the pile varies. In the second part of the process, this chenille is woven as weft into a groundwork of flax, hemp, or jute, which forms a closely woven under-fabric, not unlike the usual basis of the tapestry carpet already noticed. Figs. 48 and 49 will show clearly enough how this is done. The upper portion of Fig. 48 represents all the threads of the fabric with the chenille removed. The "back-bone" of the chenille, which in the specimen before us is composed of several strong cotton threads crossed over each other as in gauze-weaving, so as effectually to hold in the tufts, is indicated by the strong black lines *a*, *a*, *a*. Other bold black lines at right angles to these, marked *b*, *b*, *b*, show the position of what Mr. Templeton calls the "catcher-warps," or those which are put in to hold down the chenille by its "back-bone." In Fig. 49 these parts of the texture are indicated by the same letters. The remaining warp and weft threads in the figures are those concerned in the structure of the strong under-fabric. In this kind of carpet, the elements of the design or pattern exist in the chenille, which somewhat resembles the parti-coloured yarn in the tapestry carpet, only being already in tufts it does not require the extra length to provide for loops. Indeed, Mr. Templeton took out a later patent for printing the chenille and also weft yarn of various colours in a different way from Whytock's process, but which secured the same result. He also patented a method of making his "patent Axminster" carpets with a chenille warp instead of a chenille weft, and they are sometimes constructed on this latter plan.

Templeton's carpets are frequently woven all in one piece, so that occasionally the looms are more than thirty feet wide between the frames. This style of carpet, which is variously called patent Axminster, Scoto-Turkey, and Chenille, is, from the length and fulness of the firmly-bound tufts, very durable. Fair ordinary qualities of narrow widths are only about one-fourth more in value than a good Brussels, but those made in one piece, if of fine material and intricate design, are often costly, though still less so than a hand-made Axminster. Sometimes only one carpet of a particular design is made, in which case its ownership is not unfrequently marked by armorial ensigns or monograms.

Sir M. Digby Wyatt, in his report on the carpets exhibited in Paris in 1867, says, that "the four great tests of excellence in both Brussels and pile carpeting are—first, the length of loop, or pile; second, the quality of the woollen yarns; third, the number of threads to the inch in width; and fourth, the compactness of weaving at the back, so as to perfectly tie in the loops and cut filaments which form the pile. If the pile, or tufts, can be made perfectly secure from pulling out in wear, the longer they are, or rather the higher they rise from the back of the carpet, the greater will its durability be. It is much easier to tie in 'moquettes,' or little tufts of wool plaited in by hand securely (because the threads of the tuft are already intertwisted and matted together before tying), than any loop or tuft formed from wool or worsted which has been spun, or has once been brought into a state of even moderate tension; since the latter operation injures the natural tendency of the fibre to interlock. That is why the hand-worked Turkish and Indian goods are so extraordinarily durable.

Mosaic Carpets.—Some years ago Messrs. Crossley of Halifax held a patent for what was called mosaic work in wool, suitable for carpets, rugs, screens, and like articles. It is understood that, for carpets at any rate, this kind of manufacture has now ceased; but as the process, from the unlimited use of colour which it admits of, as well as from its ingenuity, is very suggestive, we shall notice it briefly here. Real mosaic work is made by using small coloured glass rods of an infinite number of shades, from any suitable one of which the artist breaks off a bit and sticks it into a base of cement, and he thus works on, breaking and sticking in another bit, and so with all his selection of tints till his picture is completed. Now, if instead of breaking off pieces, suppose he formed his picture with the ends of the rods, leaving them entire, and they were, say, ten feet long. Here, by the use of any binding-frame, we should have a picture the same as before, but instead of the coloured glass being only a fraction of an inch, it would be ten feet thick. In this way we might have more than a hundred copies of the picture, provided it were practicable to cut across the pile of glass rods, which it is not. This is exactly the plan on which the so-called "mosaic carpet" is made, only wool is used instead of glass. Frames of wire-gauze or canvas are placed at a convenient distance apart, and between these the coloured worsteds are stretched, the picture or pattern being formed by their ends. When the

pattern is made up, it is placed in a case with movable sides and open at both ends, with a solid piston attached to it, as in Fig. 51. A solution of some adhesive cement is then applied to the fibres at one end; a length equal to the required depth of pile is next forced out of the case and cut across with a knife; and finally this is cemented to a backing of rough canvas. As many as 500 copies of a picture or pattern can thus be obtained, and many strikingly beautiful objects have been made in this way.

Felt Carpeting.—Woollen goods made entirely by the felting process are worth more attention than they appear to receive. We have already described how cloth, which is first woven, is felted; and with fabrics which are not previously woven the process is, of course, in principle the same, although the construction of some of the machinery employed is different. The art of making carpets and other felt cloths has been long practised in India and other parts of the world; indeed, it is not very new in England, but as much has been done of late years by our manufacturers to improve this class of fabrics, we might expect greater results from a process in which nature meets art half way. Carpets and similar woollen goods with wholly felted textures are made in the following way, but we do not here include felt hats:—The wool is first sorted for the different qualities of fabrics, and then carded into a thin broad lap or sliver on a carding-engine of the same kind as that used in the woollen cloth manufacture. This lap, which is so thin that it will hardly hang together, is immediately passed over a series of rollers so arranged as to fold it into a number of layers. The laps or slivers are as broad as the carding-engine will prepare, and the number of layers of these thin fleeces thus folded on the top of each other varies according to the thickness of felt required. When a close and compact texture is wanted, like the felt used in polishing plate glass for example, what will in the end be compressed into the thickness of less than half an inch, may in this loose pile of carded layers require to be a foot thick. If it is requisite in the manufacture of ordinary woollen cloth so to prepare the wool that the filaments may be as free as possible for the felting process, this must of course be all the more necessary in the case of a fabric whose strength entirely depends on the completeness with which the fibres are held together by the minute serrations and waved structure of the wool. Hence the necessity of opening up all irregularly matted portions of the fleece by the teeth of carding cylinders, and of subsequently curling up the filaments by heat and moisture through the application of steam. The more hooking and interlocking of fibre with fibre the better, provided it is uniformly done all through the texture. After a proper thickness of carded sliver is made up it is passed through a series of rollers arranged as in Fig. 52, and which have a vibrating or lateral motion as well as a revolving motion. When subjected long enough to the rubbing action of these rollers, along with which steam is used, the felt is placed for a time in the fulling stocks, and then taken to the drying-house, where it is passed over another arrangement of rollers in an atmosphere kept at a high temperature by steam. Methods are in use for raising and cropping the surface of such felt fabrics as require it similar to those already described for thus treating woollen cloth.

Nothing more is necessary in finishing plain felt cloths, and such as are intended to receive a colour or pattern are dyed or printed. Carpets and table-covers are usually printed, but other felt fabrics, as slipper cloths, are dyed of one colour, and of these very large quantities have been made. By this process such articles as petticoats are now manufactured without a single seam or thread of yarn. All carefully-made felt goods look well, and it is asserted by those who know best that they are not wanting in durability. We may hope, then, that both the public and manufacturers may yet derive more benefit than hitherto from a class of fabrics, composed no doubt of a material comparatively expensive, but at the same time made by a process than which nothing much simpler could be imagined.

With this we bring our papers on "Wool and its Industrial Applications" to an end, having traced all the phases of treatment necessary to convert this useful material into the numerous fabrics of every-day use of which it forms either the whole or a part, from the first cleansing that it receives when fresh from the sheep's back to the final touches which finish its conversion into a valuable article of merchandise.

THE LATHE.—XX.

By Henry Northcott.

PLANING AND SHAPING APPARATUS APPLIED TO THE AMATEUR MECHANIC'S LATHE.

The lathes described in the last chapter are equal to the production of any kind of plain turned work in metals or wood, such as cylindrical turning for shafts, spindles, and bolts; surface-turning of face-plates, discs, collars, and cylinder covers; and angular and taper turning for circular slides, cones, tapering shafts, and connecting-rods. Any kind of hand-tool work may also be executed in them, as well as screws and spirals of any usual pitch. But these capabilities, extensive though they be, are insufficient for all the amateur's requirements. It is necessary for him that the lathe, in addition to its ordinary uses, should be able to aid in the execution of work other than turned, and Fig. 128 will show how the amateur mechanic is enabled to plane up a piece of metal by means of a planing apparatus applied to the lathe.

The lathe to which the planing mechanism is applied is a simple hand-tool lathe, as made by Mr. Munro; it has a slide-rest, shown on the ground; but this is not used at the same time as the planer. The planing machine when it is not required is removed from the bed, which is then kept clear for the usual lathe work. When in use, however, it is placed upon the bed in the position shown in the engraving. It is as well to make a couple of marks—or one will suffice—on the edge of the bed to indicate the proper place for the bed-plate of the machine, as one portion works in connection with the mechanism on the end of the lathe-bed, from which it should stand at a certain distance. The machine consists of a massive bed-plate carrying two upright standards, across which is placed a slide termed the cross-slide, and upon this is placed the tool-box or sliding tool-holder. The upper part of the machine-bed is fitted with V-grooves to convert it into a slide for the sliding table shown upon it, and which is made larger than the machine-bed. It will be understood that the machine-bed is fixed to the lathe-bed, and has no motion whatever, but the table is connected at the back, by means of a strong connecting-rod, with a crank-arm attached to a horizontal disc having a vertical spindle. The vertical shaft is driven from the crank-shaft of the lathe by a pair of bevel wheels, that one on the crank-shaft being about half the size of the wheel on the vertical shaft, so that the lathe rotates only half as fast as the former. The crank-shaft may be run from 50 to 80 revolutions per minute, the other will consequently make from 25 to 40, and the sliding table makes the same number of strokes. A parallel vice is shown, fastened down upon the sliding table, with a rough casting held between its jaws ready for planing up to form a portion of some slide-rest. The vice may, however, be removed, and the work fastened directly to the slide-table when the shape of the article is such as to render the latter plan more convenient. The work, it will be understood, travels under the cutting-tool, which, with the exception of its side-feeding motion, is held stationary. The stroke of the planing-table is made such that the work may travel a sufficient distance past the tool at each end to allow the tool to clear itself from its cut and feed-traverse taken for another. In order to allow the travel of the slide to be thus adjusted, the crank-arm is necessarily made so that its "throw" may be varied from nothing up to the full range of the machine-slide; and the point at which the rod connects the crank with the table is made movable, to allow of the limits of the strokes to be adjusted in relation to the tool. Or this latter adjustment may be effected by moving the machine-bed upon the lathe-bed.

The tool-holder may be moved the whole length of the cross-slide, and this movement gives the feed-traverse for the horizontal cuts; an upright slide is provided for the vertical cuts, and the same slide takes the angular cuts, when it is swung round upon a central pin which fastens it to the slide-plate. The tool-box encloses the tool, and it is fitted with two trunnions, which allow the tool to have a slight movement forward during the return stroke of the work, by which means the tool is withdrawn somewhat from contact with its cut, and its breakage from the friction rendered less likely. When the lathe, to which a planing apparatus is to be applied, has a slide-rest to it, it is advisable to make the tool-holder of the planing-machine the proper size for receiving the slide-rest tools, in order that one set of tools may answer for both turning and planing. The cross-slide may be

moved anywhere up and down upon the two uprights carrying it, by turning round the small winch-handle, shown at the top left-hand corner of the engraving; this motion drives two upright screws through two pairs of bevel pinions on the tops of the standards, and the screws work through two nuts fixed to the cross-slide. If a thin plate had to be planed, and it was fastened directly to the sliding-table, the cross-slide would have to be lowered to bring the tool down within working reach of the surface to be planed; but if a bulky article were fastened to the table, the cross-slide might require raising to let the work pass under the tool. The traverse for the vertical and angular cuts is got by hand, but the movement of the tool along the cross-slide is made self-acting by the levers shown at the side. These, actuated in the first place by a tappet adjusted to the sliding-bed, move round the traverse-screw of the cross-slide by a ratchet-wheel and click, and one or more teeth of the ratchet are taken by altering the throw of the lever according as a fine or coarse traverse is required. When this apparatus is to be used, the lathe-bed is cleared of the slide-rest and screw-poppet, the machine placed on the lathe and bolted down in place, the work fixed to the sliding-table either by being held in the vice or otherwise, a sharp tool placed in the tool-box, the height of the cross-slide adjusted to bring the tool within reach of the work, the crank-arm set to give the sliding-table a stroke rather longer than the cut, and the connection of the connecting-rod with the table arranged to bring the stroke in proper place under the tool. The treadle is then worked to drive the crank-shaft in either direction, whilst the tool is set into cut by moving the screw of the vertical or other slide. The contrivance is very efficient so far as its working goes, but its great weight is somewhat inconvenient. Fig. 129 shows a very neat apparatus for a somewhat similar purpose, and of which Messrs. Booth Brothers, of Dublin, are the manufacturers. It is termed a shaping machine, and is shown applied to one of their four-inch centre amateur's lathes, upon the bed of which it is bolted when required for use in the position shown, and with its left-hand driving disc engaged by the driving-pin of the lathe. The machine is capable of "shaping" (shaping is a technical term generally used for planing on a small scale) a surface 7 inches long and 3 inches wide at one setting; that is, the maximum stroke of the tool is 3 inches, and the traverse of the slide and work is 7 inches. The instrument is self-contained, and when bolted to the lathe-bed is ready for work. The motive power for driving it is obtained from the lathe-spindle, the driving-pin of which engages into a space cut in the machine driving-plate, and this connection allows the motion to be communicated without the necessity of the spindles of the two being perfectly in line, although of course they should be placed so. At the other end of the same spindle as the driving-plate there is a crank-plate with adjustable crank-pin, but the crank-pin, instead of being connected direct to the slide, is arranged to slide up and down a slotted arm, a square slide block being, however, interposed between the crank-pin and slot to increase the wearing surface. The slotted arm is fixed below upon a stud attached to the main casting or bed-plate of the machine, and the motion of the crank-pin up and down in the slot causes the arm to oscillate around this stud or fulcrum. But its motion has a varying angular velocity, which becomes greater as the crank-pin arrives at that end of the slot nearest the fulcrum, and less as it approaches the other. In this apparatus the tool moves backwards and forwards over the work in order to give the cutting stroke, whilst the work only moves sideways to give the traverse between the cuts. The slide carrying the shaping head and slide works in V's formed in the main casting, which is stationary. It receives its stroke from the slotted arm by a strong connecting-rod jointed to the middle of the slot, and at its other end to the slide by a pin which is susceptible of a horizontal adjustment. As the slot-arm oscillates it gives a reciprocating motion to the shaping slide, but owing to the varying angular velocity of the former, the slide moves forward slowly and returns faster, so that the cutting stroke is performed in a certain time and the return or idle stroke in less. The tool-slide is attached to the front of the shaping head, and is actuated by hand; this is the slide used for setting in the tool for horizontal cuts, and for the traverse of vertical and angular cuts. It is shown set for an angular cut. The tool-box is of the same form as in the last case, and a tool is shown in its place. The front of the main casting projects out over the lathe-bed,

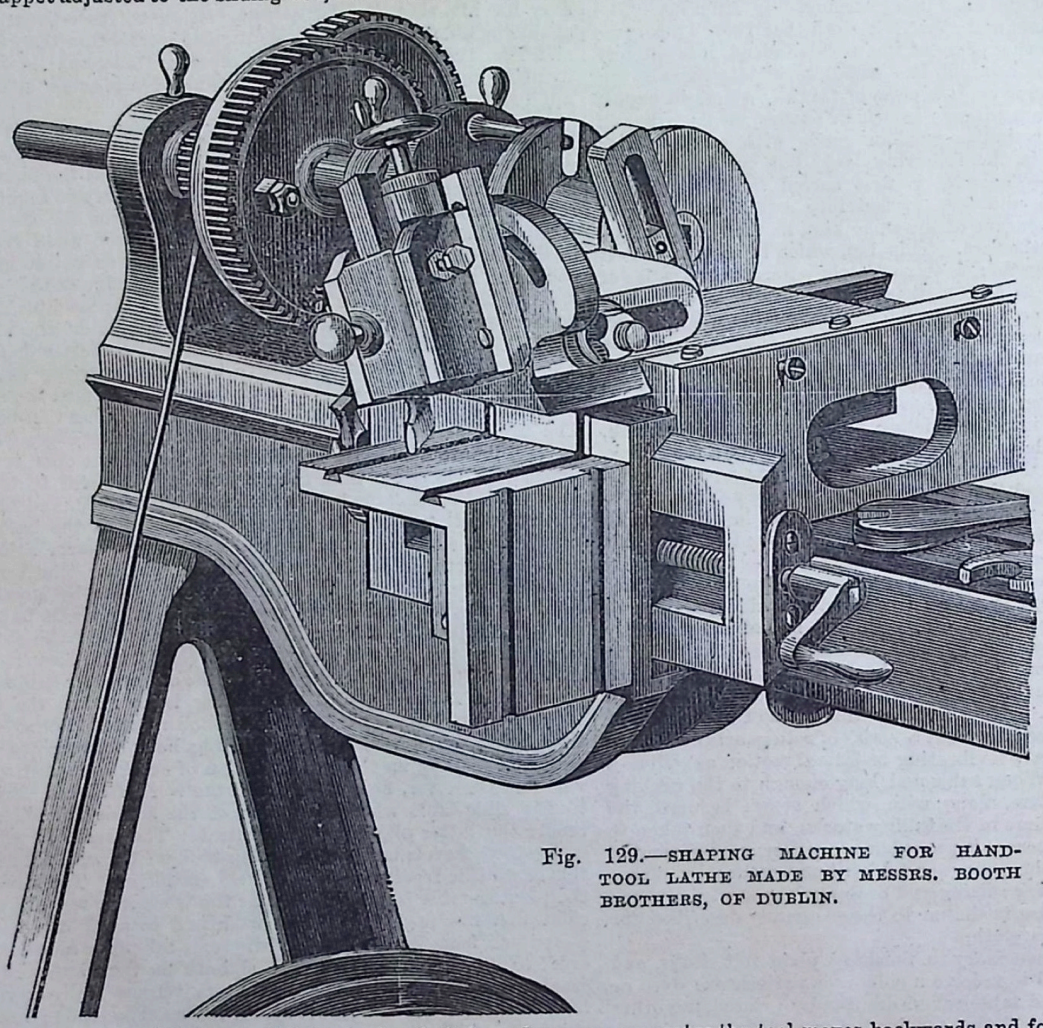


Fig. 129.—SHAPING MACHINE FOR HAND-TOOL LATHE MADE BY MESSRS. BOOTH BROTHERS, OF DUBLIN.

where it is formed into a horizontal slide furnished with a screw and winch-handle, and to the moving part of the slide is bolted an angular table to which the work is affixed. Automatic motion is given to the work by means of the mechanism seen on the left of the machine, and which consists of a ratchet and click upon the traverse-screw, actuated by a cam-groove cut in the reverse side of the crank-plate.

When the machine is wanted for use, it is placed in position on the bed, the work to be planed is attached to the angular table by a vice or otherwise, the table is raised or lowered to bring the work within cutting reach of the tool, the length and position of the stroke is adjusted, and the tool is then brought into cut. Altogether, this is one of the neatest little shaping machines I have met with. The slotted arm for the quick return of the tool is frequently used in larger machines, but Messrs. Booth Brothers have worked the whole out on this small scale in a very creditable manner, and the result is an efficient tool for the amateur's use.

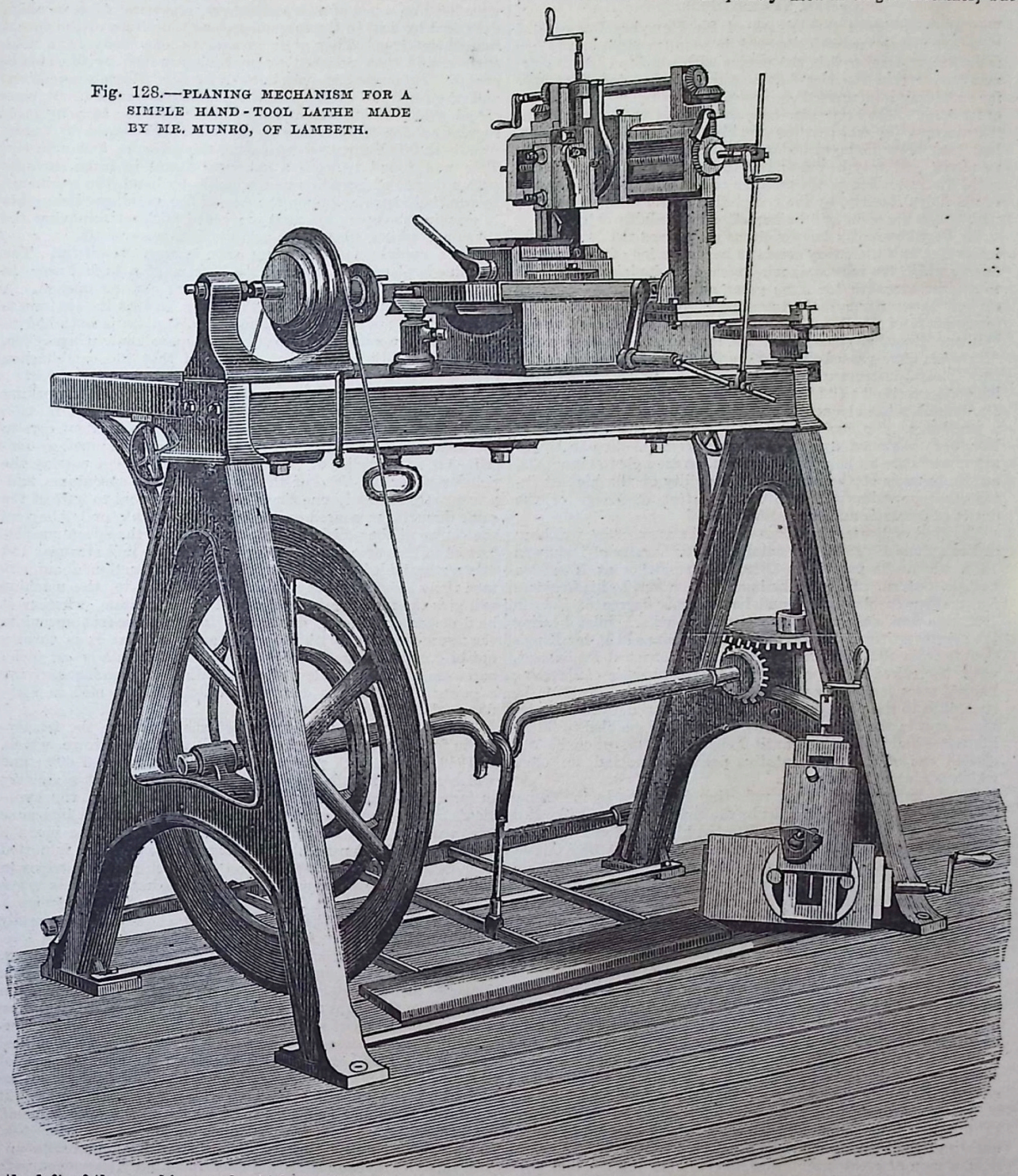


Fig. 128.—PLANING MECHANISM FOR A SIMPLE HAND-TOOL LATHE MADE BY MR. MUNRO, OF LAMBETH.

The space at my disposal will not admit of any reference to ornamental or fancy turning, which, however, although a very interesting and pleasing branch of the art, is not of the same industrial importance as the branches treated of.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XL.—THE EARL OF ROSSE, K.B., F.R.S.—GREAT REFLECTING TELESCOPES.

The applicability of the remark of Sir Humphry Davy—that "our aristocracy may be searched in vain for philosophers"—is strikingly disproved in the genius with which an Irish nobleman has, within the last half century, constructed telescopes far exceeding in magnitude and power all previous instruments of its class. The originator and architect of these magnificent instruments, the construction of which we are about to describe, had long been distinguished in scientific research as Lord Oxmantown, and may be considered to have gracefully commemorated his succession to the earldom of Rosse, and his presidency of the Royal Society, by the completion of the marvellous work with which his name will be hereafter indissolubly associated.

Sir David Brewster has felicitously observed that "the long interval of half a century seems to be the period of hybernation during which the telescopic mind rests from its labours in order to acquire strength for some great achievement. Fifty years elapsed between the dwarf telescope of Newton and the large instruments of Hadley; other fifty years rolled on before Sir William Herschel constructed his magnificent telescope; and fifty years more passed away before the Earl of Rosse produced that colossal instrument which has already achieved such brilliant discoveries." ("Life of Sir Isaac Newton," vol. i., p. 62.) Dr. Robinson has eloquently expressed his delight that "so high a problem as the construction of a six-feet speculum should have been mastered by one of his countrymen—by one whose attainments are an honour to his rank, an example to his equals, and an instance of the perfect compatibility of the highest intellectual pursuits with the most perfect discharge of the duties of domestic and social life."

The Earl of Rosse, the eldest son of the second earl, was born at York, June 17, 1800, and entered the University of Dublin in 1818, whence he passed, in 1819, into residence at Magdalen College, Oxford. He early distinguished himself by his fondness for mathematical studies; and he took his degree of B.A. in 1822 as a first class in mathematical honours. Whilst bearing the courtesy title of Lord Oxmantown, he sat as M.P. for King's County from 1821 till the end of the first Reformed Parliament, when he retired from political life for the purpose of devoting himself more completely to philosophical pursuits. In 1841 he succeeded to the peerage, but as his Irish coronet did not give him a seat in the House of Lords, he was still enabled to follow his tastes and inclinations until February, 1845, when he was elected one of the representative peers for Ireland, an office which is always held for life.

To the improvement of the reflecting telescope, by increasing its magnifying power and light by the construction of as large a mirror as possible, Lord Rosse directed his attention as early as 1828, his operations being carried on at his seat at Birr Castle, Parsonstown, about fifty miles west of Dublin. His lordship has been described as fitted for his work by a rare combination of "talent to devise, patience to bear disappointment, perseverance, profound mathematical knowledge, mechanical skill, and uninterrupted leisure from other pursuits" (Dr. Thomas Woods). Lord Rosse has been further characterised as "the great mechanic of the age, a man who, if he had not been born to a peerage, would probably have taken the highest rank as an inventor. So thorough is his knowledge of smiths' work that he is said to have been pressed, on one occasion, to accept the foremanship of a large workshop by a manufacturer to whom his rank was unknown." Like Sir William Herschel, he employed common workmen in his great works. Mr. Weld, in his excellent account of the telescope, says, "All the workmen are Irish; they were trained under the superintendence of Lord Rosse, being taken from common hedge schools, and selected in consequence of their giving evidence of mechanical skill. The foreman, a man of great intelligence, is of similar origin; and Lord Rosse assured me such was his skill that, during his lordship's absence, he felt confident that his foreman could construct a telescope with a six-feet speculum similar in all respects to that now erected."

Machinery was found necessary to grind and polish large specula, and Lord Rosse constructed and used for the purpose a steam-engine of two-horse power. He first ground and polished specula 15 inches, 2 feet and 3 feet in diameter. He next ascertained the most useful combination of metals for specula, in whiteness, porosity, and hardness, to be copper and tin. Of this compound the reflector was cast in pieces which were fixed on a bed of zinc and copper, a species of brass which expanded by heat in the same degree as the pieces of the speculum themselves. They were ground as one body to a true surface, and then polished by machinery moved by the steam-engine. Its mechanism was entirely of Lord Rosse's invention, and the result of close calculation and observation. It consisted chiefly in placing the speculum with the face upward, regulating the temperature by having it immersed in water, usually at 55° Fahr., and regulating the pressure and velocity. This was found to work a spherical figure in large surfaces with a degree of precision unattainable by hand, the workman, by working above and upon the face of the speculum, being able to examine the operation as it proceeded without removing the speculum, which, when a ton weight, is no easy matter.

"The contrivance for doing this is very beautiful. The machine is placed in a room at the bottom of a high tower, in the successive floors of which trap-doors can be opened. A mast is elevated on the top of the tower, so that its summit is about 90 feet above the speculum. A dial-plate is attached to the top of the mast, and a small plane speculum and eye-piece, with proper adjustments, are so placed that the combination becomes a Newtonian telescope, and the dial-plate the object.

"The last and most important part of the process of working the speculum is to give it *a true parabolic figure*—that is, such a figure that each portion of it should reflect the incident rays to the same focus. Lord Rosse's operations for this purpose consist—1st, of a stroke of the first excentric, which carries the polisher along *one-third* of the diameter of the speculum; 2nd, a trans-stroke twenty-one times slower, and equal to 0·27 of the same diameter measured on the edge of the tank, or 1·7 beyond the centre of the polisher; 3rd, a rotation of the speculum performed in the same time as thirty-seven of the first strokes; and 4th, a rotation of the polisher in the same direction about sixteen times slower. If these rules are attended to, the machine will give the true parabolic figure of the speculum, whether it be 6 inches or 3 feet in diameter. In the three-feet speculum the figure is so true with the whole aperture that it is thrown out of focus by a motion of less than the *thirtieth of an inch;* and even with a single lens of one-eighth of an inch focus, giving a power of 2,592, the dots on a watch-dial are still in some degree defined."

Thus was executed the three-feet speculum for the twenty-seven feet telescope placed on the lawn at Parsonstown, which, in 1840, showed with powers up to 1,000, and even 1,600; and which resolved nebulæ into stars, and destroyed that symmetry of form in globular nebulæ upon which was founded the hypothesis of the gradual condensation of nebulous matter into suns and planets. The instrument also discovered in the moon a mountainous tract near Ptolemy, every ridge of which is dotted with extremely minute craters, and two black parallel stripes in the bottom of Aristarchus. Dr. Robinson, in his address to the British Association in 1843, stated that in this telescope a building the size of the court-house at Cork would be easily visible on the lunar surface.

Lord Rosse now resolved to attempt, by the same processes, the construction of another reflector with a speculum 6 feet in diameter and 56 feet long. The focal length of the speculum is 54 feet. It weighs four tons, and, with its supports, is seven times as heavy as the four-feet speculum of Sir William Herschel. The speculum is placed in one of the sides of a cubical wooden box, about eight feet wide, and to the opposite end of this box is fastened the tube, which is made of deal staves an inch thick, hooped with iron clamp-rings, like a huge cask. It carries at its upper end, and in the axis of the tube, a small oval speculum, six inches in its lesser diameter. Dr. Peacock, Dean of Ely, walked through the tube with an umbrella up! The tube, by its exquisitely adjusted machinery, is moved with all the ease and precision of a microscope. The telescope is established between two lofty castellated piers 60 feet high, and is raised to different altitudes by a strong chain-cable attached to the top of the tube. This cable passes over a pulley on a frame down to a windlass on the ground, which is wrought by two assistants. The telescope is balanced by counter-weights suspended by chains, which are fixed to the sides of the tube,

and pass over large iron pulleys. The immense mass of matter weighs about twelve tons.

On the eastern pier is a strong semicircle of cast iron, with which the telescope is connected by a rack-bar with friction rollers attached to the tube by wheel-work; so that by means of a handle near the eye-piece, the observer can move the telescope along the bar on either side of the meridian to the distance of an hour for an equatorial star.

On the western pier are stairs and galleries. The observing gallery is moved along a railway by means of wheels and a winch; and the mechanism for raising the galleries to various altitudes is very ingenious. Sometimes the galleries, filled with observers, are suspended midway between the two piers over a chasm sixty feet deep.

The speculum was cast on the 13th of April, 1842; ground in 1843; polished in 1844; and in February, 1845, the telescope was ready to be tried. The speculum was polished in six hours, in the same time as a small speculum; and no particular care was taken in preparing the polisher. The casting of a speculum of nearly four tons was an object of great interest. To ensure uniformity of metal, the blocks from the first melting, which was effected in three furnaces, were broken up, and the pieces from each of the furnaces were placed in three separate casks, A, B, and C; then, in charging the crucibles for the final melting of the speculum, successive portions from cask A were put into furnaces *a*, *b*, *c*; from B into *b*, *c*, *a*; and so on. To prevent the metal from bending or changing its form, by reason of its weight, Lord Rosse made the speculum rest upon a surface of pieces of cast iron, strongly framed, and carrying levers to give lateral support; it is attached to an immense joint, like that of a pair of compasses moving round a pin, in order to give the transverse motion for following the star in right ascension. This pin is fixed in the centre-piece between two trunnions, like those of an enormous mortar, lying east and west, and upon which the telescope has its motion in altitude.

The impression made by the enormous light of the telescope (says the Astronomer Royal, Sir G. B. Airy) is partly by the modifications produced in the appearance of nebulæ already figured, partly by the great number of stars seen at a distance from the Milky Way, and partly from the prodigious brilliancy of Saturn. The account given by another astronomer of the appearance of Jupiter was that it resembled a coach-lamp in the telescope; and this well expresses the blaze of light seen in the Rosse instrument. By its means the flat bottom of the crater in the moon called Albategnius is distinctly seen to be strewed with blocks not visible with less powerful instruments; while the exterior of another (Aristillus) is intersected with deep gulleys radiating from its centre.

Sir David Brewster thus eloquently sketches the powers of this stupendous telescope:—"We have, in the mornings, walked again and again, and ever with new delight, along its mystic tube; and at midnight, with its distinguished architect, pondered over the marvellous sights which it discloses—the satellites, and belts, and rings of Saturn—the old and new ring which is advancing, with its crest of waters, to the body of the planet—the rocks, and mountains, and valleys, and extinct volcanoes of the moon—the crescent of Venus, with its mountainous outline—the systems of double and triple stars—the nebulæ and starry clusters of every variety of shape—and those spiral nebular formations which baffle human comprehension, and constitute the greatest achievement in modern discovery."

Sir David Brewster gives the effective magnitude of this colossal telescope compared with other instruments in the following table, which contains the number of square inches in each speculum, on the supposition that they were square in place of round:—

Names of Makers.	*Diameter of Speculum.*	*Area of Surface.*	*Names of Makers.*	*Diameter of Speculum.*	*Area of Surface.*
Newton	1 inch	1 sq. in.	Lassell	2 feet	576 sq. in.
	2·37 inches	5·6 ,,	Lord Rosse	2 feet	576 ,,
Hadley	4·5 inches	20 ,,		3 feet	1296 ,,
	5 inches	25 ,,	Herschel	4 feet	2304 ,,
Hawksbee	9 inches	81 ,,	Lord Rosse	6 feet	5184 ,,
Ramage	21 inches	441 ,,			

The Rev. Dr. Scoresby records that from the guidance we possess of the comparative power of the six-feet speculum in the penetration of space, we might fairly assume the fact, that if any other telescope now in use could follow the sun if removed to the remotest visible position, or till its light would require 10,000 years to reach us, the grand instrument at Parsonstown would follow it so far that from 20,000 to 25,000 years would be spent in the transmission of its light to the earth. But in the cases of clusters of stars, and of nebulæ exhibiting a mere speck of misty luminosity, from the combined light of perhaps hundreds of thousands of suns, the *penetration* into space, compared with the results of ordinary vision, must be enormous; so that it would not be difficult to show the *probability* that a million of years, in flight of light, would be requisite, in regard to the most distant, to traverse the interval.

Lord Rosse assures us that every object on the surface of the moon 100 feet high is distinctly visible, and under favourable circumstances even objects sixty feet in height. Rocks and stones innumerable are seen; but *no architecture, no buildings*, although such a structure as Somerset House, for instance, ought to be distinctly visible, far less a street, a village, or a town. Not a vestige of green fields, or of water, appears; although even a small reservoir, or a not very large patch of green, would be recognisable: all seems desolate. There is something awful in such a desert solitude. But the earth, too, has its desert wastes. Can it be, that what we do see of the lunar surface is but its desert districts, while what we do not see is not unlike the face of our own planet elsewhere than in its solitary districts? There is an ingenious theory of the moon consistent with such an idea; and we cannot see how the quibbling question of the lunar rotation can subvert the inferences and conclusions based upon that theory. Let us suppose that the lunar form is that which would naturally arise from the operation of the centrifugal force on a (once?) fluid sphere revolving, and say even rotating, round its primary, so as always to present the same phase towards the primary, that is, towards the centrifugal centre. Would not the fluid mass of the sphere so revolving and rotating be centrifugalised out of the strictly spherical form, and become oblate with its greatest diameter in the line of the radius uniting it with its primary? And if there existed even a fluid ocean and an atmosphere on the surface of such a sphere, would not that ocean and that atmosphere be also centrifugalised or driven outwards to the hemisphere farthest from the primary? In such a case, the base, as it might now be called, of the oblate sphere, or its hemisphere next to the primary, might well be a desert waste, without a drop of water; while the exterior hemisphere, invisible to us, might for all that be full of life.

COTTON-SPINNING.—V.

By J. Robertson.

THE MULE AND THROSTLE-FRAME.

We have now to consider one of the greatest trimuphs of mechanical art, so complex and intricate as to make each separate movement a complete study in itself, and yet perfectly reliable in its action. It is a notable instance of the success with which human ingenuity has sought to master the laws of force and matter, and render the materials with which we are surrounded subservient to our wants. To give anything like an adequate description of the self-acting mule is impossible within the limits of this paper. The multiplicity and complication of wheels and levers are so great, and their arrangement and construction are so varied by the different makers, that all we shall attempt will be to describe the general working and appearance of the machine, the principle of its more important movements, and the part each has to perform.

As has already been stated, the mule is now made to contain from seven hundred to nine hundred spindles. These are arranged, at distances varying from an inch to an inch and a half, upon the "carriage," or movable part of the mule, in one long row, which is interrupted at the middle for about thirty inches by the "headstock." Here the principal machinery is located, and from this the different movements are communicated. A beam stretches right and left from the headstock supporting the drawing-rollers. Behind this beam stand the creels which hold the bobbins of roving received from the fly-frames.

The appearance of the mule and arrangement of the more prominent parts of it will be understood by referring to Fig. 1, in which the headstock is shown with a portion of the carriage, creels, etc. Within the carriage there is a tin cylinder which, by means of small cords or bands, drives the spindles, and

along the top of the spindles stretch two wires called the "fallers," one of which guides the yarn upon the cop. Between the roller-beam and the creels the *back-shaft* extends to each end of the mule, where it is furnished with pulleys, which, by means of a cord fastened to the carriage, and passing round a fixed pulley upon the end-piece of the mule, at the extremity of the "draw," take the carriage out. This shaft is driven by the main-shaft, which is placed on the upper part of the head-stock, through a series of connecting wheels. At the end of the main-shaft there is the "rim," or fly-wheel, which drives the tin cylinder by means of an endless double band passing round carrying pulleys.

The bobbins of roving are set in the creels upon pegs made of hard wood, and having their lower extremity tapered to a fine point. These revolve upon a glazed earthenware step, so that the friction is reduced to the smallest possible degree. Were it otherwise, the slender half-spun roving would break under the strain of unwinding. From the creels the roving passes to the drawing-rollers, guided by means of steel plates with slots. Between the first and second roller there is another row of guiding plates, and both of these are moved backwards and forwards longitudinally by means of an excentric, so that the roving may not run continuously on one place, which would cause the speedy destruction of the leather clothing. The rollers are similar to those of the machines already noticed, but not quite so large, being generally about one inch in diameter. They are in three sets: the first and second merely take in the cotton, whilst the third draws it to the size required. These drawing-rollers are adjustable to suit the staple of the cotton. The speed of the first roller is fixed, and from it the other rollers are driven by means of wheels and pinions, so that by changing these the spinner is enabled to alter the size or count of the yarn. The weights are in some cases hung upon the front top roller alone, whilst the back ones press with nothing but their own weight upon the lower ones. In others, by means of saddles, the weight is distributed over all three. Upon the top of the front roller, and also underneath, there are cleaners placed for lapping up loose waste or untwisted roving. The cotton having passed the rollers, reduced to the requisite grist, is twisted by the spindles, which at the same time move slowly backwards from the beam. This movement of the carriage is slightly in excess of the circumferential velocity of the front rollers, or of the rate at which the cotton is delivered by them, and the excess is called the "gaining" of the carriage. It has for its object the prevention of looping or doubling up, which, but for this stretching, might take place in the thread. The spindles are inclined towards the rollers at such an angle as admits of the thread slipping over the top, and no winding up takes place. So soon as the carriage has receded to the end of the "draw" or "stretch" — which usually extends to about sixty inches—it stops; but the spindles still continue to revolve until the proper quantity of twist has been imparted to the yarn. They then make a few revolutions backward until the corresponding number of turns of yarn which run up to the point have been unwound. Simultaneously, the wire of the front faller comes down upon the threads, and guides them upon the spindle or cop as the carriage returns gently to the beam. Then the faller resumes its former position, and the carriage begins a new stretch. To keep the yarn at a uniform degree of tension whilst the winding on is taking place, was one of the most difficult problems to solve in the early attempts to introduce a self-acting mule. This is now admirably done by means of the "counter-faller." During the period that the carriage recedes from the beam, whilst the spinning is being done, the wire of the front faller or guide remains stationary at a short distance *above* the threads, and close by the point of

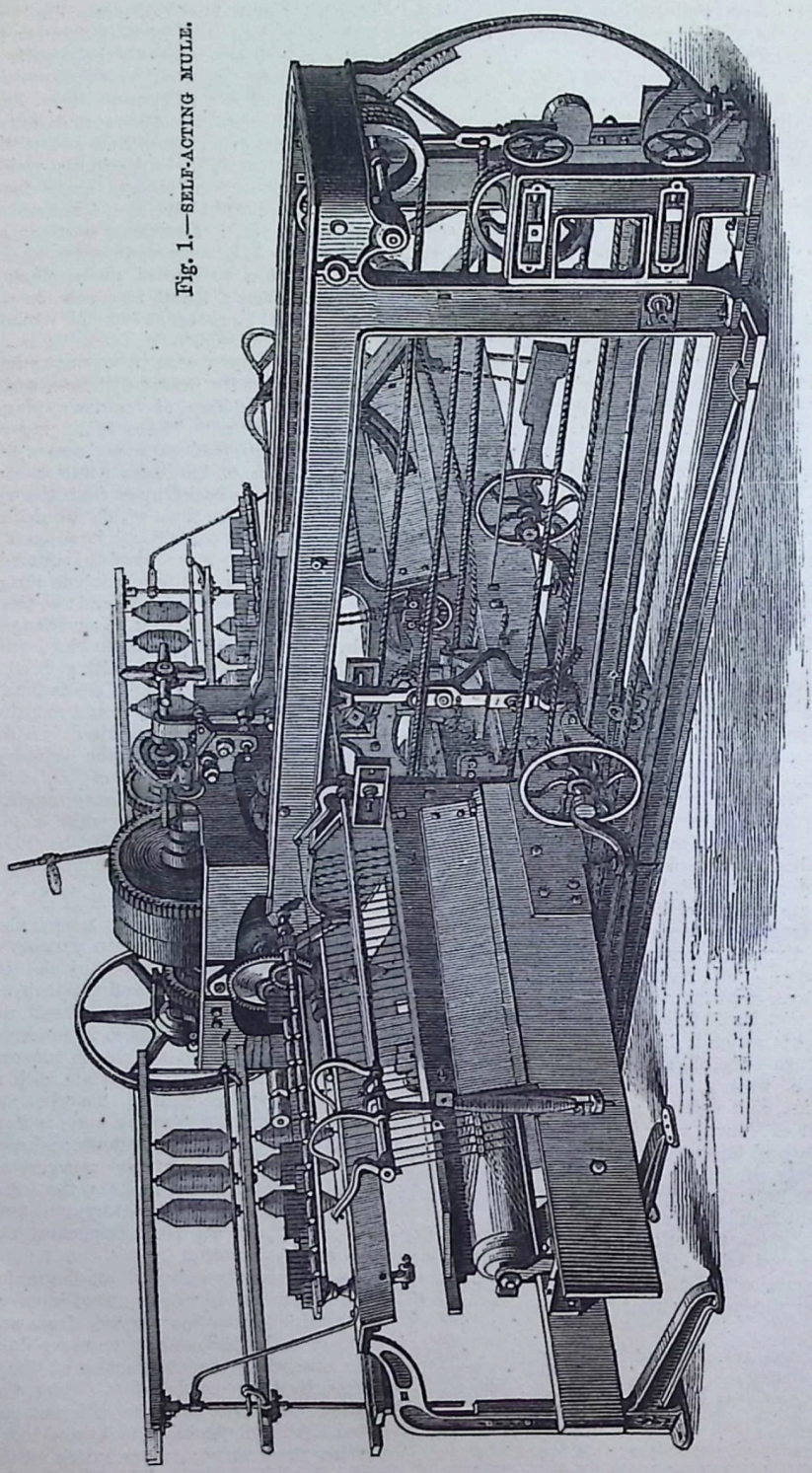


Fig. 1.—SELF-ACTING MULE.

the spindle, whilst the position of the counter-faller wire is *under* the threads, and a little further off the spindle (see Fig. 2, in which A is the front faller, and B is the counter). Both have a tendency to rise, being acted upon in the one case by a strong spiral spring, and in the other by weights; but the front faller is stopped at its proper position by a catch, whilst the other is held by a chain connecting it to the first. Now when the spinning is finished, and the front faller is depressed for the purpose of guiding the yarn upon the cop, it slackens the chain and sets the other free to rise against the yarn. To prevent the strain which would be brought upon it from the two wires striking it suddenly in opposite directions, the counter-faller is relieved of its weight by a short inclined plane fixed to the floor (C) at the end of the stretch; and only when the carriage has commenced its return movement does the weight-lever D glide off the incline and the wire bear with its full pressure on the thread. This pressure is regulated to make a firm, compact cop without unduly straining the yarn.

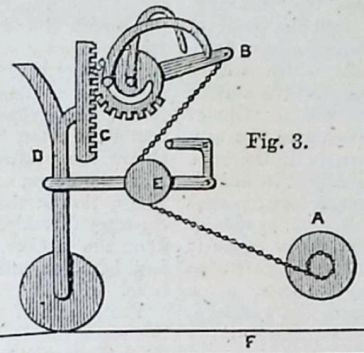
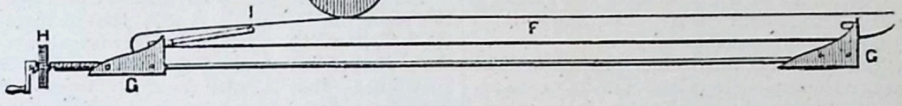


Fig. 3.



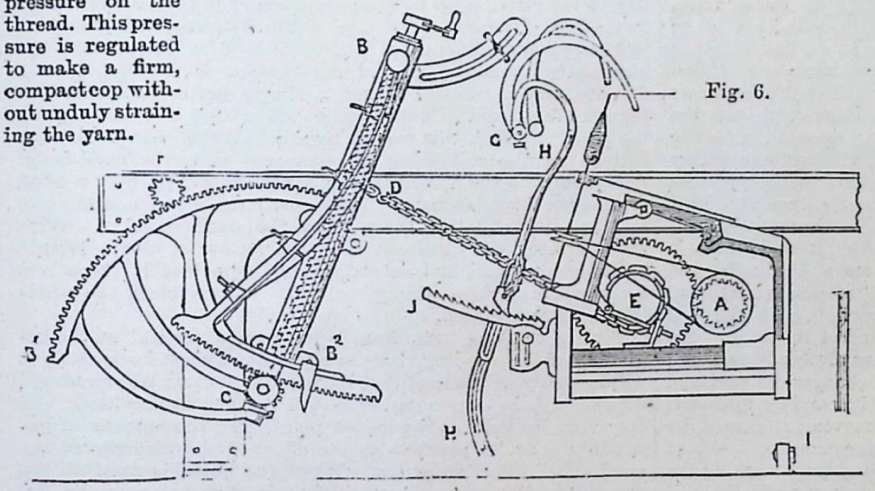


Fig. 6.

Fig. 4.

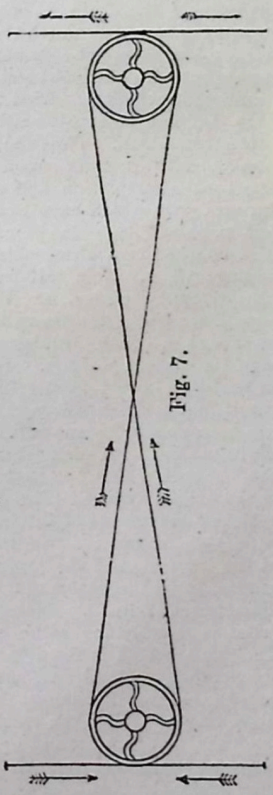


Fig. 7.

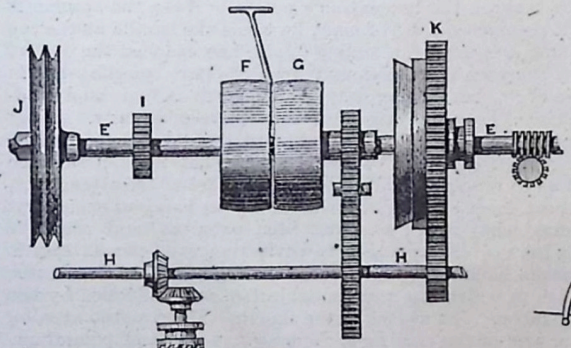


Fig. 2.

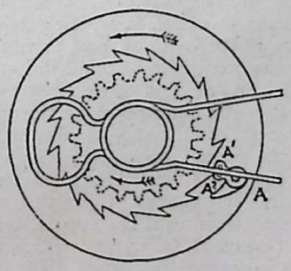
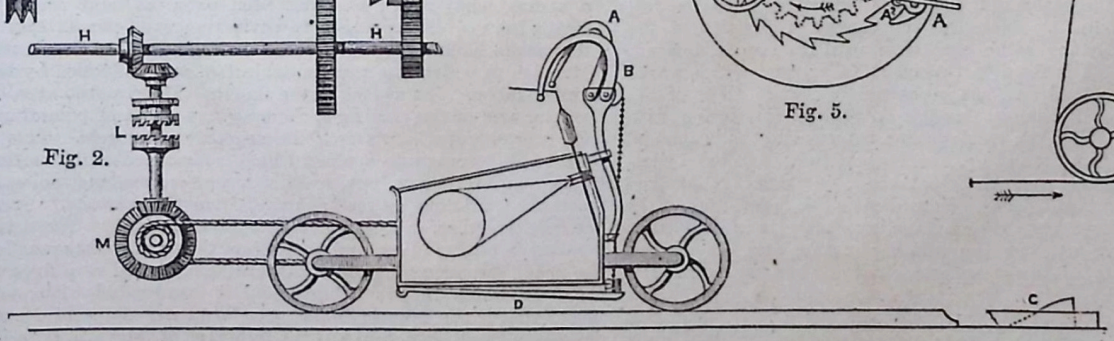


Fig. 5.



Motion is given to the spindles, as has already been said, through the main-shaft, E, placed on the upper part of the head-stock. Upon this shaft there are two pulleys, one of which (F) drives it; the other (G) runs loose upon E, and communicates an independent motion to a second shaft (H). Besides driving the spindles by the rim-wheel J, the main shaft drives the taking-out motion of the carriage, and also the drawing-rollers by means of a series of wheels (I) and two clutch-boxes.

When the carriage has reached the extremity of the stretch, it comes in contact with a projection upon a lever or rod, which either directly, or through a second lever or cam-shaft, disengages the clutch-boxes of the back shaft and of the rollers. At the same moment the action of a powerful spring is brought to bear upon the oscillating belt-guide, tending to throw it off the pulley which drives the spindles. This force is held in check by a small catch until the yarn has received its proper amount of twist, when the catch is lifted by a finger. Instantly the belt or strap passes on to the other pulley, and the spindles cease to revolve. A worm upon the end of the main shaft, and pinions which are calculated to give the twist for the particular yarn which is being spun, work the finger. As a rule, the quantity of twist to be given increases with the fineness of the yarn, so that the *twist-pinion* requires to be changed when any material alteration is made in the count of the yarn.

The driving-strap is now running upon the second pulley G. Upon the shaft underneath, which is driven by it, there are two wheels, the first driving a large friction-box (K) revolving loosely

upon the main shaft, in an opposite direction, and the other, by means of an upright shaft, driving a clutch-box (L) communicating motion to the scroll-pulley M. The same movement which has thrown the strap upon the second pulley brings the friction-box into conjunction with the corresponding friction-cone *fixed* upon the main shaft. By this means the "backing-off" motion is communicated to the spindle until the turns of thread between the cop and the point of the spindle have been unwound, when, by another piece of mechanism, which will be explained afterwards, the friction-box is set free, and the clutch-box driving the two scroll-pulleys comes into action. One of these scroll-pulleys has a rope attached to it and to the carriage, so that when motion is given to it, it winds up the rope and draws in the carriage to the beam. The object in having the pulley of a scroll, or rather of a double scroll form, is that the motion of the carriage may be gentle at first, gradually increasing as it goes in, until near the beam, when again it diminishes. The other pulley has its scroll set opposite to this, and gives out a rope at the same rate as the other takes it or winds it up. This serves as a check upon the carriage, which, by the force of inertia, might outstrip the speed which the taking-in scroll-pulley is calculated to give.

The coping or building motion is illustrated by Fig. 3. The "backing-off" motion, which has already been alluded to, as reversing the spindle just before the winding up takes place, causes the chain which is attached to the tin cylinder A to be wound upon a small barrel which is loose on it, but which is acted upon by means of a small catch-wheel when the motion of the cylinder is reversed. The winding up of the chain draws down the arm B, which is fixed upon the faller-rod, until the toothed bar C is raised up to the shoulder upon D. As the pressure of the chain is brought upon D, through the pulley E, and the bar upon which it is fixed, D yields to the pressure when C has passed the shoulder, so that C rests upon it. This movement of the upright rod D communicates through the bell-crank upon which E is fixed to the friction-box, K, and clutch, L (Fig. 2), simultaneously setting the first free and bringing the other into action. Thus the "backing-off" motion is continued always until C rests upon the shoulder of D. As the cop approaches completion, and gets near the end of the spindle, the turns of yarn which have to be unwound are always decreasing; but D, as will be seen immediately, also changes its position. D is attached to a wheel which runs with the carriage upon the coping rail, F. This rail has a vertical movement caused by the triangular plates, G. When about to commence a set of cops these plates are drawn forward by the spinner turning the handle at H, which operates by means of screws until the rail is at its highest position. This throws the guiding wire of the faller to its lowest point before it rests upon the shoulder of D. From this position the coping rail is gradually lowered as the cop increases by means of a ratchet-wheel, H, which receives a slight motion with each return of the carriage, and screws back the "shaper plates," so that the yarn is built upon the spindle in the shape required (Fig. 4). As at first there must be just sufficient movement of the faller-wire upwards upon the spindle with each successive winding as shall make an abrupt taper at the lower end of the cop, the incline upon the plates is very gradual until the bottom of the cop is formed, or until the full diameter is attained. After this the change of position of the faller is exactly the same each time until the cop is finished. The wheel which is fixed to the front faller, and which works the toothed vertical bar, has a concentric slot to allow of the counter-faller rod passing through it without interfering with its working. When the carriage has returned to the beam, and the yarn has been wound up, the upright bar D touches a carefully-set projection upon the stock-head, by which it is knocked from under the toothed bar. Immediately the fallers rise to the position they have when the carriage is receding from the beam.

We shall now consider the winding motion and the method by which the spindles are made to revolve when the carriage is returning to the beam. Revolving loose upon the shaft which connects the cylinders at the headstock, there is a wheel and disc which are geared to a barrel whose bearings are fixed upon the "square" (the strong iron plate which connects the two parts of the carriage at the headstock), and which therefore moves with the carriage. From the barrel a chain extends to the "quadrant." This chain is wound upon the barrel, as the carriage recedes from the beam, by the unwinding of a cord which has a weight attached to it. As the chain is held by the quadrant it is unwound as the carriage returns, and the consequent motion of the barrel is communicated to the spindles in the following way:—Upon the cylinder-shaft close by the disc, there is keyed a ratchet-wheel. Attached to the disc and working in this wheel there is a small movable catch having a tail-piece with two small pins. Between these two pins an arm of a friction-spring which clasps a stationary collar, is passed in such a way that it raises or depresses the point of the catch according as the disc is moved contrary to, or in the same direction as the cylinder; the friction of the spring as it is carried round the collar being always sufficient for this purpose. Fig. 5 shows the position of the catch when the carriage is moving from the beam, and until after the backing-off has taken place. The action of the chain is then felt, and the disc moves in the contrary direction, which immediately brings down the catch upon the ratchet, and carries it round with it, and the cylinders and spindles are, of course, also carried round at the same time.

The length of yarn to be wound upon the spindle is always the same, as it always equals the traverse of the carriage; the speed of the carriage is likewise always the same during the period of building. But until the full diameter of the cop is attained—that is, until the abrupt taper is finished—the quantity of yarn wound up by one revolution of the spindle is always increasing. Just as in the case of the fly-frame the ingenious and complicated differential motion is used to compensate the constantly increasing size of the bobbin, so in this, a most delicate and ingenious, though a simple device is adopted to regulate the speed of the spindles when they are winding up the yarn. Indeed, this may be regarded as the great distinctive feature of the self-acting as compared with the hand-mule. Let us refer to the accompanying illustration (Fig. 6). B B^1 B^2 represents the "quadrant," which oscillates upon a stud at C, and has its oscillation given it by the small wheel F. With every stretch the quadrant describes an arc of 90°. Within the long arm B B^2, and extending its entire length, there is a screw which works a sliding block, D. To this block the winding chain is attached.

Now as the long arm, from being nearly vertical at the beginning of the winding, falls to a position almost horizontal, it will be easily understood that the amount of chain unwound will depend in some degree on the position of the sliding block. If the chain be held at the lowest point, then the amount of unwinding is at its greatest as the effect of the yielding by the quadrant is at a minimum. When the chain is fixed at the extremity of the arm, there will be less of it unwound, by the distance between the two extreme points. When the spinner is about to commence a set of cops, he turns the handle at the top of the long arm until the sliding block has reached the lowest point, if the yarn is to be wound upon the bare spindle; but in the case of "tubes" being used, which gives an increased winding surface, he stops short of this correspondingly. Many appliances are in use for the adjusting of the chain as the spinning proceeds, more or less efficient, but none of them so perfect as to render watchfulness on the part of the attendants, and an occasional shifting of the screw by the hand, unnecessary. An arrangement which has just been patented, and which is perhaps the nearest approach to perfection, is shown at Fig. 6. All motions having for their object the regulating of the degree of tension to which the yarn is subjected, are controlled by the counter-faller. Let us look at the sketch. Upon a stud at B, on the long arm of the quadrant, there swings a sort of pendulum, the lower end of which forms the segment of a circle. This is toothed and works into a wheel which communicates its motion to the quadrant-screw, but, from its peculiar construction, *only* when the pendulum moves backward from the carriage. From the counter-faller, G, a long arm, H H, is suspended. When the winding is taking place, and just before the carriage has reached the beam, this arm comes in contact with a jointed stop fixed to the floor, which throws it back, and it is adjusted with such nicety that if the counter-fuller wire be in the slightest degree depressed lower, on account of the tightness of the yarn, than its normal position, a shoe, sliding loosely upon H H, and suspended by a short chain, takes hold of the toothed rack J, and keeps the arm from falling back against the carriage. On account of the rack being nearly straight, and that part of it which is next to the carriage being nearest to the centre of the arc described

by the loose shoe, its tendency to catch decreases the further back it goes; so that just in proportion to the depression of the faller, is the point at which the arm H is held back, and consequently the amount of traverse it gives to the pendulum when it comes against it through a projecting stud or casting. The movement of the pendulum is communicated to the screw, and the sliding block to which the chain is attached moves towards the extremity of the arm.

When the carriage returns to the beam, and the quadrant assumes a position almost horizontal, the pendulum by its weight swings forward until stopped by a projection upon the sliding block D. Consequently from the shape of the pendulum it will be seen that the greatest traverse is given to it at the beginning of the cop, and that the position of the chain alters more and more slowly until the full diameter is attained, when it ceases altogether. The building of the yarn is then uniform, in the shape of a cone, the yielding of the quadrant being always suited to this, so that the spindles revolve more and more rapidly as the faller guides the yarn from the greater to the lesser diameter.

When the yarn is finer than No. 70 or 80, it is usual to give it a slight stretch after the rollers have stopped, which has the effect of making the thread more even and uniform. An inch to five or six inches, according to the size of the yarn, is about the extent of it, and whilst it is being given the carriage recedes with a greatly diminished speed. Upon the under side of the carriage there are wheels placed in a horizontal position, round which the "squaring bands" are passed, as shown at Fig. 7. These bands are fixed at four points, at the extreme limit of the stretch in front and behind, so that the longest mules are kept comparatively rigid and free from vibration, and also parallel with the beam. At both extremes of the stretch there are stops placed, against which the carriage butts as it reaches these points, so as to cause a positive stoppage of every part.

The hand-mule is much simpler than the self-actor, as several of the movements, such as bringing the carriage back to the beam, and the building of the yarn upon the spindle, are imparted by the spinner. These mules are now principally confined to the spinning of very fine counts.

There are two kinds of yarn spun upon the mule—namely, warp and weft. The latter is ready for the loom when it is taken from the spindle, and is consequently made of a size to suit the shuttle. To render the shuttling of the cop a matter of as little nicety as possible, by preventing the closing up of the aperture which the spindle has left, various expedients have been resorted to. The most common is a small paper tube about an inch in length upon which the yarn is built, and which projects a little from the bottom of the cop. Another is the putting of a little paste or gum upon the first few turns of yarn, which hardens, and is then capable of retaining in some measure its cylindrical form. The spindles upon weft mules are placed usually not more than 1⅛ inch apart, as that is sufficient space to admit of an ordinary-sized cop. Weft for reeling—that is, to be put up in bundles of hanks—and warp yarn are not restricted in this way, and therefore the spindles are set about an inch and a half apart, and are made somewhat stronger, to prevent vibration. A cop in this case may contain from three to four times as great a length as in the other. Of course it will easily be seen that the advantage is obvious in the less frequent stoppages for doffing.

The throstle-frame is never used for spinning weft, and rarely for warp of a higher count than No. 30. This machine has changed but little in form or principle since the days of Arkwright's *water-frame*. In appearance it resembles the fly-frame, but the bobbins being smaller there are many more of them—300 to 400. The flyers, which revolve at a speed of 4,000 or 5,000 per minute, build up the yarn about the same rate as the front roller delivers it. The bobbin is dragged round by the flyer at its own speed, less the quantity of yarn wound up; and the yarn is kept tight by the bobbin being placed upon flannel washers, which tend to retard it without breaking the thread. The strain of pulling the bobbin round prevents fine counts from being spun upon this frame. The building of the yarn is caused, as in the case of the fly-frame, by the rising and falling of the rail, which is worked by means of what is called the "heart motion."

With this description we must draw to a close our series of papers on cotton-spinning as carried on in this country, and the machinery employed in the work. The comparatively limited space at our command has necessitated a concise treatment of the subject, but not an incomplete one. It would doubtless be easy to go into fuller detail upon nearly every branch of the processes employed, but we think sufficient has been said for our purpose. Considering the vast amount of capital and labour expended upon the spinning and manufacture of cotton in this country, we may hope that our remarks upon this subject will not be among the least useful or interesting to the readers of THE TECHNICAL EDUCATOR.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

XX.—SCHOOL MUSEUMS (*continued from Page 375*).

A TRANSVERSE section of the typical school museum described at considerable length in our last paper, showing the arrangement of the end of the lecture-theatre, and exhibiting a sectional view of the museum, observatory, and watch-towers, is given in Fig. 38, upon the next page. D, B, S, C, D, shows the range of doors, battery, sand-bath, and stink-cupboards behind the lecture-table; and L, the disc used for the lantern diagrams, etc., above it, this being eighteen feet in diameter, painted on the surfaced wall with baryta-white paint, which does not discolour in the same way as white-lead pigments. G shows the side-galleries of the theatre. Above is seen the museum, M, with its wall-cases, W, and angle-lighted roof, A A. V V shows the position of gas-pipes and ventilators of the museum, which will come into use when it is lighted up at night. Behind is seen the astronomical observatory, O, surmounting the tower that forms the lift-shaft, the stack of chimneys above the laboratory flues, F, and a watch-tower, T, that surmounts the spiral staircase, and by a door gives access to the roof.

The *Astronomical Observatory* requires careful consideration in connection with the details of construction of any building intended for science schools, as it must be so placed and arranged that the floor on which the telescope stands shall not be subject to any vibrations from without. The best arrangement is to build up a brick tower from a solid base: preferably this should be conical in form, and filled with dry sand, but it may be hollow, the top being covered with a thick stone slab, on which the telescope-stand is fixed. This supporting tower must be quite isolated from contact with the floor on which the observer stands, and also from the walls of the observatory. In my typical plan of construction I have provided for the observatory by making the walls of the lift-tower double, the outer being those ranging with the main building, the inner an isolated hollow shaft, within which is the lift that conveys table-cases, specimens, instruments, etc., from the museum to the lecture-room or laboratories, so that any vibrations from the various floors, walls, etc., cannot be imparted to it, as it is in no place in contact with them, as represented in elevation in Figs. 37 and 38, the latter diagram also indicating the position of the stairs, S, from the floor of the Arts School, by which access is gained to this observatory, and the manner in which the telescope-stand is isolated from the floor and walls of the observatory.

The proportions of the external walls of this tower will depend upon whether a refracting or reflecting telescope is to be adopted, for as the former requires that the observer should lie on his back, it demands greater space than for the latter, where the observer stands in the more convenient position, *beside* the instrument. An observatory 6 feet square would be sufficient for Browning's "Educational Reflector," of 4½ inches diameter and 5 feet focus, provided with alt-azimuth and parallactic motions, designed especially for school purposes. It is well to bear in mind that, while a good reflector is as efficient as a refractor, it is considerably cheaper; but those interested in the question of reflectors *versus* refractors will find the subject fully discussed and illustrated in Mr. Browning's "Plea for Reflectors." To secure equality of temperature, the walls of the observatory should be made of sheet iron, extra space being at the same time gained. A small room for the reception of a transit instrument should be connected with the observa-

tory, or the tower T (Fig. 38) might be made available for the purpose. A large tank should be placed on the roof, to keep the laboratories well supplied with water.

Such a range of buildings would provide ample and suitable accommodation for teaching science in our great schools on a proper scale, and if at first sight this typical plan is suggestive of heavy outlay, we may fairly ask if costly piles have not been erected for the very simple requirements of classical and mathematical instruction, and whether science, so intimately associated with modern professional occupations, has not equal claims for buildings adapted to its special necessities. There need be little fear but that ample funds will be forthcoming to provide both the necessary materials and structures, when such testimony as the Masters of Rugby bear—in answer to the question, "What are the general results of the introduction of science teaching?"—has been multiplied. Mr. Wilson answers this question for the body of masters as follows:—"In brief it is this, that the school as a whole is the better for it, and that the scholarship is not worse. The number of boys whose industry and attention is not caught by any school study is markedly less; there is more respect for work and for abilities in the different fields now open to a boy; and though pursued often with great vigour, and sometimes with great success, by boys distinguished in classics, it is not found to interfere with their proficiency in classics, nor are there any symptoms of over-work in the school. This is the testimony of classical masters by no means specially favourable to science, who are in a position which enables them to judge. To many who would have left Rugby with but little knowledge, and little love of knowledge, to show as the results of their two or three years in our middle school, the introduction of science into our course has been the greatest possible gain; and others who have left from the upper part of the school, *without hope of distinguishing themselves in classics or mathematics, have adopted science as their study at the Universities.* It is believed that no master in Rugby School would wish to give up natural science and recur to the old curriculum."

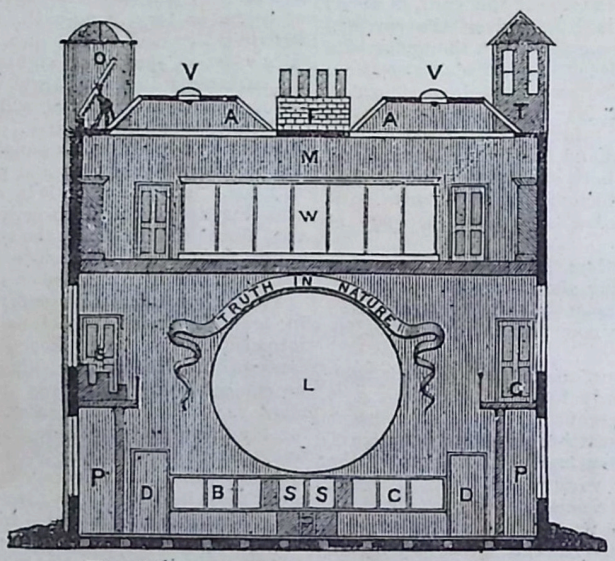


Fig. 38.—TRANSVERSE SECTIONAL VIEW OF SCHOOL MUSEUM.

Construction of Local Museums.—The term "Local Museum" has been applied to such small collections, housed in small rooms, as the late Mr. Toynbee described in his little book on the Wimbledon Local Museum; but here I employ the term in its wider and general sense, as applied to provincial museums of all descriptions that aim at displaying "typical collections," as well as "local collections;" for they exist under such a variety of names, I hardly know how to select a better designation of general significance, unless it be the term "provincial museum;" but I include such institutions as that recently opened at the east end of London, under the title of Bethnal Green "Branch Museum" of the South Kensington Department of Science and Art, as an example of similar branch museums to be established in other parts of London and its suburbs. In the construction of our local museums, the scientific man has unfortunately seldom if ever been consulted as to the practical wants of the curator or lecturer; but the entire design has been left to the architect, who, as a rule, is perfectly unconversant with scientific requirements, and thinks it beneath his dignity to confess as much, and seek the advice of those who could aid him; while, guided by the instincts of human nature, he throws all his thought into general "effect," especially over the exterior, which will be a standing advertisement of his architectural ability to those who are town councillors—not naturalists! Thus it is, money has been lavished over the music-hall-like interior of the Hartley Institution of Southampton, and the massive Gothic exterior of the Devon and Exeter Albert Memorial Museum. In the former case, the lecture-hall is more suited for concerts and town council addresses than for lecture purposes, being of great length, the floor occupied with seats on a uniform level, the sides with two tiers of galleries, like the boxes of a theatre, with a great semi-circular concert-gallery, entered by large doors at the back, immediately above the head of the lecturer; so that it is difficult to make the voice heard and experiments seen by all the vast audience the place is constructed to hold. As might be expected, the space available for the museum is small, and that required for other scientific purposes is totally unprovided for; though the object Mr. Hartley specially had in view when he made the munificent bequest of over £89,000 was for the benefit of "the select scientific public." At the Exeter Museum the Gothic walls are *over two feet thick*, which consequently leads to many of the rooms being badly lighted, including those devoted to the typical and ethnological collections on the ground floor. The top-lighting of the "local museum," on the upper floor, is marred by a side-light in addition, which produces an effect of glare. *There is no lecture theatre*, and some of the best rooms formerly devoted to science classes have been annexed for extra reading-rooms for the free library. Much space is wasted over the entrance arcade, vestibule, staircases, etc., and a number of little rooms in the front of the building, which would have been turned to good account if any scientific person had been consulted; the architect having given more attention to the external effective appearance of his design than internal conveniences for scientific requirements, and so much money was devoted to this mistaken end, that little was left for providing necessary cases for the proper display of an extensive and excellent collection of general and local specimens, a large portion of which are obliged to remain packed away, instead of being displayed for public inspection. Having given two well-known examples of architectural miscarriage in relation to museum construction, I may state that I believe the elastic typical plan I have given for the science buildings of a school will equally meet the requirements of a local museum, if we replace the external staircase leading to the first floor with a large and handsome double staircase, and build in front, to the height of the three stories, a large and lofty entrance-hall, entered from without by a pillared portico, preferably of a size that would admit of carriages being drawn up beneath it. The sides and front of this entrance-hall might have the window spaces fitted with large and lofty plant-cases, for the ornamental display of palms, tree ferns, and other tropical shrubs, plants, etc. The room P N, forming the natural history work-room in the school arrangement, might in this case be devoted to a reading-room. I see no reason why a building that is professedly a museum should not have its doors and windows treated, internally, as illustrative specimens of different styles of architecture in different ages. The selection of the heating apparatus of a public institution requires care, or it may prove a matter of great annoyance, if not injury to health. I believe the hot-water system is usually preferred to the hot air, as the latter is considered unpleasant, and the smell from the flues is often very objectionable. In building any local museum, the first effort ought to be to produce a shell, fitted with the most convenient arrangements human ingenuity can devise for the wants of curator, teacher, and student, and when *that* has been accomplished, *then* devote any surplus funds to the external ornamentation of that shell in any manner good taste may direct, as long as the design will not interfere with the effective lighting of the several departments; at least, this is *the naturalist's*, if not *the architect's*, view of the question.

PRACTICAL APPLICATION OF THE FINE ARTS.—XVI.

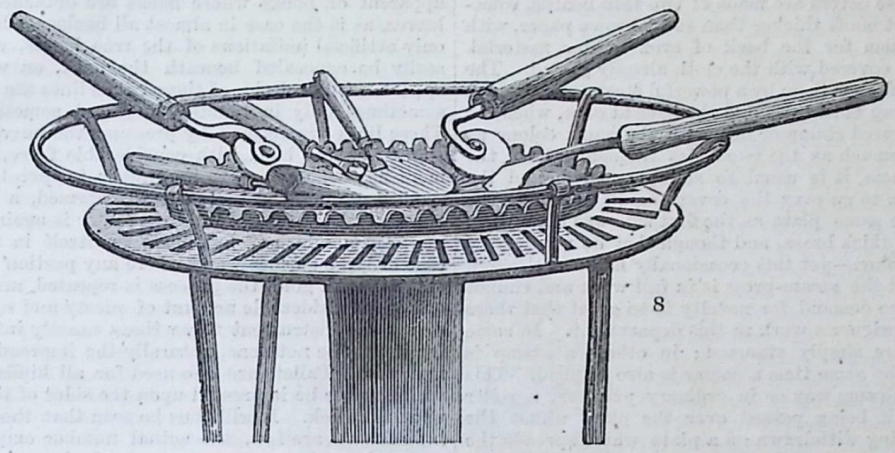
By P. H. Delamotte, Professor of Drawing, King's College, London.

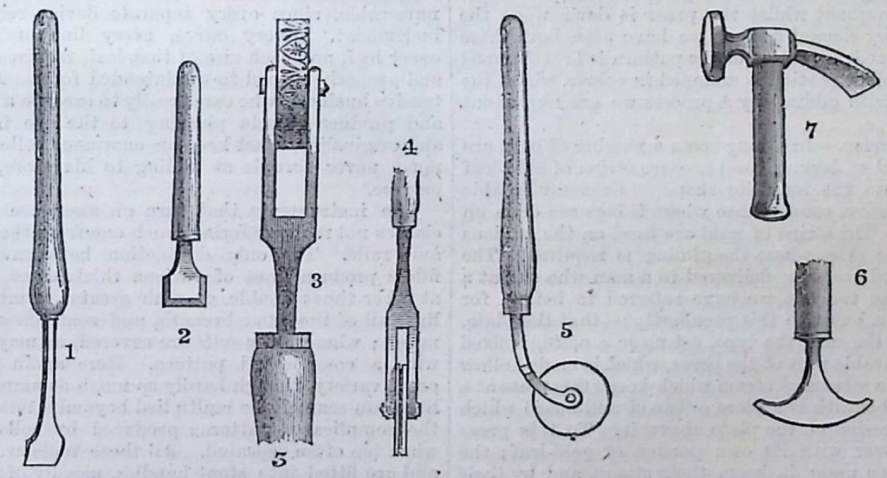
THE ART OF BOOKBINDING (*continued*).

Cloth Binding.—In France and Germany it is the habit of publishers to sell their books simply in a paper wrapper, the sheets being folded, but not even stitched as our magazines are. This would not suit the English market, where many books are sold which the buyers do not care to have bound in a strong and consequently somewhat expensive cover, and yet which, being read by several persons, require something more than loose paper to keep them together. This applies not only to novels and ephemeral publications, but many more substantial works which are bought for perusal at the time, their owners waiting for a more convenient time to have them fully equipped to join the serried ranks upon their book-shelves. Hence the wholesale cloth binding for publishers. There are many points in this style of binding which differ from the stronger and more expensive work.

Sawing the Back.—In the first place the sawing the backs is done by machinery. The sheets being folded and compiled, several copies of the work—the number of course depending upon the thickness, *i.e.*, the number of sheets of each copy—are taken by a workman, who drops them on the flat plate of his machine on their backs first, and next on their top edges, thus getting all these portions quite flat; then holding the whole mass of sheets with the backs downwards, between his hands, he slides them along the steel plate, keeping the top edges against a guide placed at the back, and in this way they traverse over some circular saws, the teeth of which rise a quarter of an inch above the plate. The number and distance apart of the saws depend, of course, on the number of bands it is intended to give the work, and these can be regulated either with screws or stops on the spindle on which the saws turn. The saws leave a shallow groove in the backs, which just penetrates the sheets as far as the crease, thus making a slight hole for the sewer's needle to go through, saving both time and labour in pressing the needle through, and also allowing the band to be within the groove. The bands must needs be sewn on evenly with this line to guide the thread. With this assistance a woman can sew as many as two or three thousand sheets in a day. Sometimes tape bands are used instead of string. The women employed in this work get as much as fourteen shillings a week. After the bands are sewn the whole back is often covered with a piece of canvas, which extends about half an inch beyond the paper, and which when glued to the boards affords some additional protection to make up for the want of security in not running the bands through the boards, which is seldom done in rapid work.

Backing Machine.—The backing is another process that is done by machinery. The book is placed in a press between two iron plates, leaving about half an inch raised above the press, the pressure being applied by the foot whilst a steel roller of some two or three inches diameter is brought down by the hand upon nearly the centre of the back; this roller, the axis of which works on arms, which allow it to move backwards and forwards to and from the operator in the arc of a circle, is pressed downwards on the back, and moved first to one side and then to the other, pressing the back out in each direction, and leaving an ample margin, so that the boards when applied sink into a place ready fitted for them. The crease in this case will be perfectly even and smooth, but the amount doubled in will be greater in most cases than when the work is done by hand with the backer's hammer. Even in this case, however, the hammer is not entirely dispensed with, for when the books are thus pressed it is necessary to give them a blow or two first to ensure their taking the right direction under the roller. With this machine a single man can back as many as twelve hundred books in a day, whereas by the hand the time taken to each book is considerable, and the larger the book, and the better the style of binding, the longer becomes the process.





TOOLS, ETC., USED BY BOOKBINDERS.

1. Polishing Iron. 2. Pallet. 3. Roll. 4. Two-line Roll. 5. Fillet. 6. Pallet. 7. Hammer. 8. Gas-stove for Heating Tools.

Cutting the Edges.—The books are now roughly cut by a large knife which works by steam-power. This is only a preparatory process in order to avoid rough and uneven edges, and it does not do away with the necessity for the paper-knife, but after the work is put into boards it is often cut again; this is a more delicate and careful process, though similarly performed.

Covers.—In this kind of binding the boards and their cloth covering are applied at the same time, and all pasted on at once to the back and bands, canvas and lining sheets. The preparation of these covers forms a remarkable exemplification of how far machinery can be adapted to the multiplication of beautiful forms. When we look at some of the charming cloth covers which about Christmas time especially we see lying on booksellers' counters, resplendent with bright colours, covered with elegant designs, and with portions of their designs stamped in other colours and lavishly bedizened with gold, it is scarcely possible to imagine that large editions of such works, consisting

of one, two, or three thousand, have passed through the binders' hands with only three or four days elapsing from the time that the sheets left the printer's workshop until the time when the publishers had the works returned to them in a state fit to put forth in all their glory and splendour, before a public which has to be captivated with a new, striking, and elegant cover. But such is frequently the case, and whilst we were inspecting the Temple Works, belonging to Mr. Matthew Bell, we were shown covers then only in the first stage of preparation, the sheets to go inside which were not yet arrived from the printers, but of which 1,000 copies had to be delivered to the publishers in but little more than forty-eight hours from the time we were there. The mind can scarcely conceive much more rapid work than this.

Stamping.—These covers are made of two thin boards, somewhat firmer but not much thicker than stout brown paper, with a strip between them for the back of even lighter material. These three are all covered with the cloth already glazed. The pattern is impressed upon them by a powerful steam-press, which will if required stamp both sides and the back at once, when the back has an uncoloured stamp or one with the same colour as the sides; but inasmuch as the two sides frequently have the same design on them, it is usual to stamp one side and the back first, and then to go over the covers again, stamping the other side with the same plate as the first side was done with. These plates are of thick brass, and though they do not readily wear out or get broken—yet this occasionally happens through displacement whilst the steam-press is in full work and cannot be stopped—still the demand for novelty is so great that there is much room for designer's work in this department. In some cases the covers are simply stamped; in others a stamp is imprinted, and at the same time a colour is also applied. This is done much in the same way as in ordinary printing, a roller covered with the ink being passed over the plate whilst the press is up, and being withdrawn on a plate which spreads the ink by constant movement whilst the press is down upon the cover. In some very elegant designs we have seen both these elements are combined; a portion of the pattern is first stamped plain, and then another portion is stamped in colour, whilst the whole is enlivened with gilding by a process we are now about to describe.

Gilding and Lettering.—In a long room a number of boys are seated each at a kind of desk. These prepare strips of gold-leaf by cutting them into the requisite shape. Economy in this respect is of the utmost consequence where things are done on such a large scale. The strips of gold are fixed on the various parts of the back or sides where the gilding is required. The covers thus prepared are then delivered to a man who sits at a press very similar to the one we have referred to before, for stamping the boards, but with this peculiarity;—that the plate, or, as is sometimes the case, the type, set up in a plate, is fixed to the upper and movable part of the press, which is made hollow for the reception of a stream of steam which keeps this plate at a fixed temperature; beneath is a piece or two of mill-board which has taken the impression of the plate above it. To this press is subjected the cover with its own portion of gold-leaf; the hot plates come down upon it, leave their stamp, and by their warmth fix the leaf within the sunken parts. The cover is now returned to a boy, who wipes off with a piece of rag the superfluous gold, which is easily detached, and it is finally rubbed well with Indian rubber.

Paper Covers.—For very cheap books paper-covered boards are prepared, only that instead of being stamped they are printed. This gives scope to any amount of variety, and not only a pattern, and the name of the book, but also a scene from the subject of the work, printed in one or more colours, is not unfrequently given, together with advertisements on the back.

The covers thus prepared are simply glued and pasted to bands and lining paper, and then it is ready for the common use to which such works are subjected. The strength, of course, of such work is not great, and it is not intended by these temporary covers to do away with the necessity of more substantial binding for books that deserve more attentive perusal than much of the current literature of the day demands.

BOOKBINDERS' TOOLS, ETC.

The instruments used in the ornamental portion of bookbinding, though innumerable in actual detail, may be classed under very few heads; in fact, they may be arranged into those that are fixed and those that turn on their own axes. Those that are fixed are called pallets, whilst those that turn are named fillets and rolls. Amongst our illustrations, Nos. 1 and 7 are distinct implements. The first is a polishing iron, for smoothing the backs of books, and the last is the hammer used in backing, to which we referred in a former paper; neither of these can well be reckoned among the instruments in the ornamental portion of bookbinding.

Pallets.—Pallets are used where a certain definite figure has to be impressed, as, for instance, the tool from which our illustration 6 is taken, is employed to mark the double lines which we commonly find on each side of the false bands on the backs of large books. The reader will remember that the bands which are apparent on books whose backs are detached from the actual leaves, as is the case in almost all books at the present day, are only artificial imitations of the true bands, which must necessarily be concealed beneath the back, on which false bands appear. On each side of these bands lines are usually impressed, sometimes only in blind-tooling, and sometimes with gilding. These lines are formed by pressing the curved pallet, such as Fig. 6, on the back with considerable force, after the instrument has been heated to the proper temperature. If the lines require gilding, the tool is again warmed, a piece of gold-leaf is attached to the tool, and the latter is again pressed into the impression which it has made for itself in the back. In the case of large surfaces, and where any portion has been left uncovered with gold, the process is repeated, and of course it requires a considerable amount of nicety and some experience to direct the instrument three times exactly into the same spot, for if this be not done, naturally the impression is blurred and irregular. Pallets are also used for all kinds of small devices, which are to be impressed upon the sides of the book as well as upon the back. It will thus be seen that though the classes of instruments are few, the actual number employed may be innumerable, since every separate device requires its separate instrument. Every curve, every line of various thickness, every leaf, and each size of that leaf, requires to be cast in brass, and properly shaped to the intended form. A man with an extensive business, who cares really to execute a variety of designs, and produce objects pleasing to the eye from their variety and originality, must keep an enormous collection of tools, and must never scruple at adding to his store, however large it may be.

The instruments that turn on axes are divided into two classes not really differing much one from the other—viz., fillets and rolls. The only distinction between these is that the fillets produce lines of various thicknesses, sometimes single, at other times double, or with greater numbers, sometimes the lines all of the same breadth, and sometimes of different thicknesses; whereas the *rolls* are covered, as may be seen in Fig. 3, with a complicated pattern. Here again there is room for great variety, though hardly so much as among the fillets, since lines can scarcely be multiplied beyond a moderate number, and the complicated patterns produced by rolls are not pleasing when too often repeated. All these tools are formed of brass, and are fitted into stout handles, usually of ash, since they are used with a considerable amount of force.

Temperature.—The process of heating requires great care and large experience. Each kind of leather requires a different temperature. In order to simplify the acquirement of the necessary heat, a small gas-stove, such as is portrayed in our illustration, is made use of. In the centre is a modified form of the Bunsen burner, and above this is placed an iron dish having a hole in the centre, which allows the direct heat of the flame to ascend through it, and which also has a couple of rims raised around it with a number of notches in them. These notched rims retain the tools at any distance from the central flame, the handles being supported on a bar surrounding the whole apparatus. The tools can be made to rest on this in such a manner that they can be heated quickly over the hot flame, or they can be kept at any temperature whilst other work is being pursued or another tool being used. When the tool is sufficiently heated it is applied to the leather, which is damped either with weak acid or with water, as we described before. The instrument is held in the right hand, near the junction of the brass and the wood, and the end of the handle rests against the shoulder. The amount of pressure is then produced by the leverage be-

tween the hand and the shoulder. In the case of pallets curved as in No. 6, by the workman leaning forwards or backwards the various portions of the edge are brought in contact with the different parts to be impressed; and in like manner with the rolls, the gradual motion of the whole body produces a uniformity of pressure which ensures an evenness in the pattern. Where direct pressure alone is required, the position of the workman may be seen in Fig. 3, page 41 of the present volume.

Proportion.—Another most important point in design must be the keeping a proper relative proportion between the various parts. We constantly see that a certain plain space has to receive some kind of ornament; the tools are looked over, and one is chosen which, by turning on one side perhaps, will just fill up the space. Here all proportion is lost. If a drawing or an engraving is put into a frame that just fits it, half the effect is gone; let it, however, be allowed a margin which is half as wide as the picture itself, and the effect is enhanced in a marvellous manner. If a star is enclosed in certain boundaries, the points of the star should not pierce the sides of the figure by which it is surrounded, but it should have a certain space to shine in. In order to make the indentations of the pattern appreciated, there must be a considerable expansion of even surface with which to compare and contrast it. Even surfaces must contrast with highly ornamented parts, and the foundation colour should form a foil for that which is inlaid on it. An agreeable effect, too, is produced by the gold or deep-coloured border-line stopping where another pattern comes across it, and thus producing the appearance of the one pattern crossing the other. This should be sparingly indulged in, for, if frequently employed, it becomes wearisome.

Time and Study.—For all these variety of details it is necessary that time should be employed. It is impossible to produce a really good design in a short time, and if experience may afford a seeming facility, it is only because forms used before recur to the memory and come into employment again. As in all designs, the general idea must first be sketched out, and afterwards the details finished; it is useless to begin upon the details and try to fit the design to the detail afterwards. Mere running lines about, without any object, will not eventuate in any pleasing work unless the eye has the power to choose out the beautiful among a variety of worthless designs. So, too, colour should not be put on unless it be to express some clearly-defined idea. Books for constant reference, or on serious and important subjects, are better covered in deep and sober colours undiverted by lighter tints; but works which are designed more to amuse than instruct should repeat in their covers the lightness and variety of their internal ideas. So, too, with the temporary covers in which publishers send out works; these necessarily are of a lighter and brighter character than the more permanent clothing that books receive when they have a place assigned to them for repose on the shelves of the library rather than of the reading-room. We give a specimen of a cloth cover, which will serve to illustrate our remark. The design should be light, but it is not only so in design; the nature of the material allows of a great variety of colour, and naturally striking colours are most attractive in the eyes of those who wish to draw attention to their wares. But though the designs on cloth covers are to be attractive and striking rather than grave and solid, there is no reason why good taste should not prevail in their production. The combination of lines may be boundless, and without being eccentric there is plenty of room for variety and for beauty. One great fault to avoid is the overcrowding of ornament. As the exterior case is not intended to last for any great length of time, there is no occasion to squeeze all the ornamentation we can think of into a small space. Both publisher and reader wish rather to be able to distinguish the work by its cover, than to be led to examine minutely the lines of beauty on the outside. Variety of colour, therefore, is a primary consideration. This of course is easy enough now-a-days, with the innumerable dyes and the facility for modifying the various tints of each colour. Upon these various tints, both gold and other colours, and especially black, can be printed. It is scarcely possible, therefore, to go far wrong as regards colour, for there is no temptation to multiply colour when each additional printing costs more, and the brightness of the impressed colours is naturally to a considerable degree lost. Black or a dark colour upon a single tint, relieved with a small amount of gold, which will add naturally to almost every tint, leaves but small room for mistakes in regard to colour. The principal point, therefore, in cloth binding is form. Now a study of the combination of lines in all kinds of ways is the only means to increase taste in the matter of lines. Of course a true artist has the purest appreciation of the value of lines. A course of study in an art-school will do much to produce a true taste in this matter. And as all artists are recommended, when they wish to prepare themselves for any course of painting, to study the anatomy of the human body, and to draw from the living model, so no one can hope to accomplish really satisfactory designs who does not go to Nature to discover the secrets of her graceful combinations of lines in all natural productions of the animal, vegetable, and mineral worlds. It must be remembered, however, that in these designs we are not reproducing Nature, and in bookbinding a very good lesson in ornamentation is soon brought home to the student. He cannot, with the very limited materials for producing lines which are at his command, reproduce the infinite variety of natural objects; but what he has to do is to idealise natural objects, and then to introduce all the variety of their application he can. Nature, for instance, never gives a straight line, but in a design for a cover we *must* have many straight lines. The curve which a natural object suggests is never fully carried out; there are always imperfections, breaks, interruptions, new ideas breaking in; the brass tool must be of a perfect curve, or it is useless; interruptions are scarcely permissible; old ideas must be fulfilled before new ones can be entertained. That which causes the charm of natural objects, the constant development of something fresh, is entirely unsuited to the ornamental design. If a man therefore intends to work out a design, of which some particular kind of leaf or flower is to be the groundwork or the leading principle, he will not copy one solitary leaf, however beautiful in itself, but after studying (best with pencil in hand) a great number of examples of the object proposed, he will then, laying aside the work which he has done, draw such a leaf or flower as he has never yet seen, but such as all these various examples have pointed out as the model from which they have more or less departed. He may then advance another step, and noticing the peculiarities which distinguish this kind of leaf from the others with which it is most closely allied, he may exaggerate those peculiarities, leaving out the portions in which his model is similar to other leaves. In this way he arrives at a mere ornament like the fleur-de-lis or the star, neither of which is, excepting in a conventional way, suggestive of the name it bears.

SPECIMEN OF MEDALLION ON A CLOTH COVER.

In some of the examples we have given, a single leaf is made the foundation of the greater part of the ornament: we may instance the work of Nicolas Eve and Belz-Niédrée. The lines and curves of the twigs are numerous and varied, the leaves are put on these twigs in various ways, but the leaf is the same, not even a difference of size. Nothing can be more elegant and refined than the conventionalised oak branches in Belz-Niédrée's work. The curved lines, not at all such as one would really find in oak branches, contrast most pleasingly with the severe straight lines and sharp angles of the rest of the pattern. The thickly placed leaves in the other, with the constantly recurring berry between every two leaves, is also unlike anything in Nature that one has ever seen; yet the effect is pleasing, and it has for its foundation these natural objects.

The binding of Grolier and his men (Grolieri et Amicorum; not Grolier and his hands, or his workmen, but his friends—what master now so describes his assistants? how would not such a man love his work and the books he preserved, who thus

spoke of his associates in the work ?) is a good example of rich yet simple design. In the centre is a species of quatrefoil suggesting a cross, longer in the direction of the length of the book. The lines next the edges are parallel to those edges, and unbroken until they approach the corners, when they take a sharp circular curve inwards, and in this respect are more pleasing than other examples of the same artist. These two sets of lines are combined by the inner border parallel to the outer one it interlaces; the inner figure, again, by its rhomboidal shape surrounds the quatrefoil, and it also touches the outer lines. All these lines, therefore, are interdependent upon one another; they are all different in character, and yet are all combined and are suggestive of one another. Nothing has been used so far but straight lines and portions of circles, but these portions have been all different, and the straight lines of various lengths. There remain spaces to be filled up. In order not to suggest weakness at the corners, a rather elaborate ornament is introduced which entirely fills up the space. This is not independent, but by a delicately curved line is attached to the outer line of the border. Each of the blank spaces is then filled in with ornaments which adapt themselves to the position they have to take, but at the same time leave an ample margin round each. For instance, a conventional rose in the three-quarter part of the circle suits its position admirably, but it is not repeated in those leaves of the quatrefoil which are broken by a straight line. Again, in the border, where long spaces are left between the points of the diamond and the corners, a cipher introduced takes the main outline of an oblong; the little flowers at the corners of the inner border line are turned on one side, but it is in order to point to the corners to which they approach. Thus all is pleasant and harmonious, and a design is produced which requires no artificial assistance from colour, but which nevertheless would easily admit of its introduction.

A careful study and analysis after the above manner of the best works of Maoli, Le Gascon, Clovis Eve, Nicolas Eve, Hardy-Menil, Belz-Niédrée, Banzonet, and our great English binders, will well repay the time and labour expended upon them.

CIVIL ENGINEERING.—XXVI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BRIDGES (*continued*).

BEFORE raising the superstructure, it is necessary to determine the strength and thickness of the abutments which have to resist the thrust of the arch. The difference between the functions of the piers and the abutments of a bridge is very marked. In the case of a single arch with two abutments, although the key-stone and voussoirs effect an equilibrium amongst themselves, yet the whole together exercise a very considerable amount of lateral thrust against the spring on either side. The amount of such thrust will vary with the curve of the arch, but in every case it is very great, and must be carefully guarded against. In the case, however, of a bridge consisting of two or more arches, the abutments still have to bear all the lateral thrust, whilst the office of the intermediate pier is simply to sustain the weight of the superincumbent masonry, because the two opposite springings of the arches balance their respective thrusts, or else simply transmit the thrust to the next arch, and finally to the abutment. Hence a pier may be made as light as is consistent with the duties it has to perform, so as not to impede unnecessarily by its size the water-way, as already adverted to.

The strength of an abutment is a point dependent upon various conditions, such as the flatness of the curve with which the arch is struck, the weight of the arch, the height of the abutment, and so forth.

The following formula will give the thickness of an abutment without wing-walls, possessing quite sufficient strength to resist the thrust of the half-arch, supposing the same material is employed both in the arch and the abutment, the depth of the crown being equal to $\cdot 4\sqrt{R}$, in which R = radius of arch at the crown in feet:—T (the thickness) $= \sqrt{\frac{R^2}{5} + \frac{3R^{\frac{3}{2}}}{5} + \left(\frac{W}{H}\right)^2} - \frac{W}{H}$, in which W = weight in cwts. of 1 foot lineal of half the arch, and H the height of the abutment to the spring in feet.

Another point of importance, independent of the thickness of the abutment, is the tendency of that portion of it from the line of thrust upwards to slide back over the masonry below this line. Now here it is evident no precise rule can be given for the avoidance of such a result. It is a question dependent principally upon the material employed as mortar or cement, added to the weight of the superincumbent mass. The question of the adhesion of cement and mortar is one of great interest to the engineer. In 1804, M. Boistard published some experiments upon the subject, and the conclusion he arrived at was what might have been expected—that the adhesion of mortar is proportioned to the surface, and that after the lapse of a few weeks the value of the adhesion ceases to increase. He considered that the adhesion of a square metre of surface of set mortar, composed of lime and sand, was equal to 15,312 lbs., and if composed of lime and cement to 8,140 lbs., both results being regarded approximately. With respect to the friction, the same author ascertained that it bears a constant relation to the superincumbent pressure, being equal to about four-fifths of the pressure: and here it may be observed that the flatter the arch the greater is its tendency to induce a sliding action in the upper portion of the abutment, simply because the thrust is more horizontal; whereas, the more curved the arch, the greater is its tendency to overturn the abutment. In both cases, however, one fact becomes

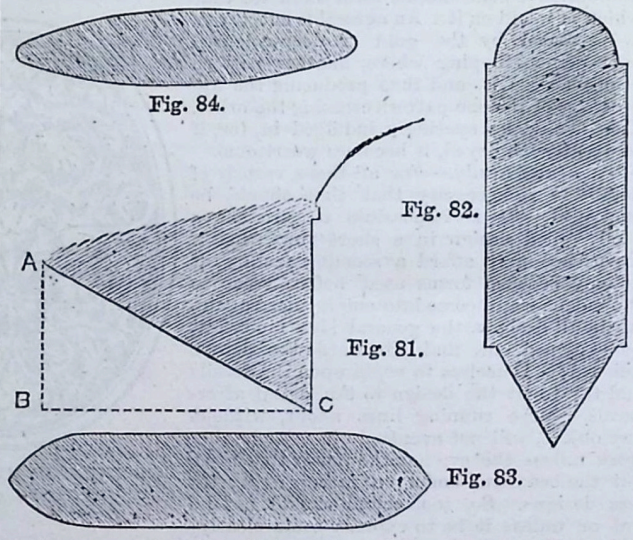


Fig. 84.

Fig. 82.

Fig. 81.

Fig. 83.

obvious—namely, that that portion of the masonry below the line of thrust serves no other purpose than that of supporting the actual thrust-resisting mass above that line, and hence any undue quantity of material may be dispensed with. One plan of avoiding this waste of material is to construct walls in the line of thrust, and to turn upon them arches of small radius, upon which the mass of the upper portion of the abutment rests, care being taken that the height to the crown of the extrados of these arches does not rise above the line of thrust. Another method is to incline the base of the abutment towards the arch, as shown in Fig. 81, whereby the mass of material included in the space A B C is avoided.

We have stated that the function of a pier is mainly that of supporting the actual weight of masonry resting upon it, and of transmitting the thrust of the adjacent arches. This is correct, and in this view only the size of the pier may be advantageously reduced to a minimum. But other considerations have to be dealt with. It is proper to consider what would result in the possible event of a pier being carried away from some unforeseen cause. Supposing any pier in a prolonged series of arches were removed, and each of the other piers could do no more than fulfil the functions stated above, it follows that the equilibrium of thrust being removed by the fall of one pier and its adjacent arches, all the others must yield in succession to the one-sided thrust thus brought to bear upon them, and the ruin would become general. For this reason it is desirable to give to a pier which is associated with other piers in the same bridge a greater amount of strength than is actually required for the fulfilment of its purpose as a pier. As an illustration of the dif-

ference between theory and practice in respect of the dimensions of a pier, it may be stated, in the bridge at Neuilly, constructed by Perronet, the piers are about 14 feet in thickness, whereas the same engineer has calculated that they would perform their functions as *piers* if reduced to 13 inches, although with such a reduced area the stone composing the pier would be supporting a weight sufficient to crush it. But whatever be the reduced dimensions of the body of a pier, care at least should be taken that the base is spread over a considerable area.

We have in a former part of our treatment of this subject alluded to the forms of the "starlings", of the piers of bridges. The starling is that portion of the pier which faces the direction of the stream, and acts like the cutwater of a ship. The ancients were in the habit of giving the form of a semicircle, or else a triangular form, to the starlings of their piers, as shown in Fig. 82, and we are not prepared to find great fault with them; but modern engineers have made the matter a subject of calculation, and the usual form now adopted is that of a Gothic arch, as shown in Fig. 83.

It is, however, a remarkable fact that if the starling is altogether omitted, and the pier terminated abruptly, presenting a flat surface to the current, the flow of the water is less obstructed. There is a reason for this apparent contradiction. As the current strikes against the opposing pier it becomes in a measure heaped up, and forms in consequence a mass of dead water extending not only along the entire face of the pier-end, but for a certain distance past the angles; and this mass acts as a guide to the succeeding current, warding it off, as it were, from the pier, and giving it a regular and gentle flow past the sides. But the danger resulting from the regular flow of a current is, in its effect upon a pier, small as compared with the danger arising from the undermining of the pier itself. The contraction of the water-way must obviously increase the rapidity of the stream, and this, it has been shown, acts detrimentally upon the bottom. Now the action of a flat starling or pier-head is to throw the current away from the pier itself, and to divert it into the middle of the adjoining arch; here, therefore, there is a concentration of the current, and a consequent increase of velocity. This should be avoided.

The results obtained from a series of experiments made with starlings of various forms have been to give a preference to the elliptical pier-head, making, in fact, the section of the entire pier an elongated ellipse, as shown in Fig. 84.

If a triangular form be adopted, the equilateral is preferable to the right angle; but the form given in Fig. 83 is an excellent one, and presents, at the same time, a lightness in character which is agreeable in an architectural point of view.

The actual construction of piers and abutments is a matter of the greatest importance; a good foundation will in this case avail but little if the superstructure is imperfectly united. Hard stone should always be selected for the purpose, and the outside courses should be laid in headers and stretchers alternately. The size of the stones must depend upon circumstances, but they should not be too long. Less care in regularity may be observed in the interior filling in, but this also must be substantially put together.

After the piers and abutments are raised, and sufficiently consolidated, the centres are put up, and rest upon projections left for the purpose in the sides of the piers, or upon piles placed close to them. They should rest directly upon double wedges, so that they can be adjusted bodily accurately to the exact height required. The voussoirs can now be placed in position; and to prevent an undue pressure upon the centres, they should be laid from each side simultaneously, and close with the key-stone. Care must be taken that the line of joints between the respective voussoirs corresponds accurately with the radii of the arch at those points. The thickness of the crown of an arch will depend upon the radius of the curve with which the arch is struck. No certain rule can be laid down for this, but experience has shown that it may vary from less than 6 inches in an arch whose radius is only 2 feet, if the material be stone, to about 4 feet if the radius be 160 feet. If brick be used, these dimensions must be considerably increased—namely, from ·56 ft. in the former to over 5 feet in the latter.

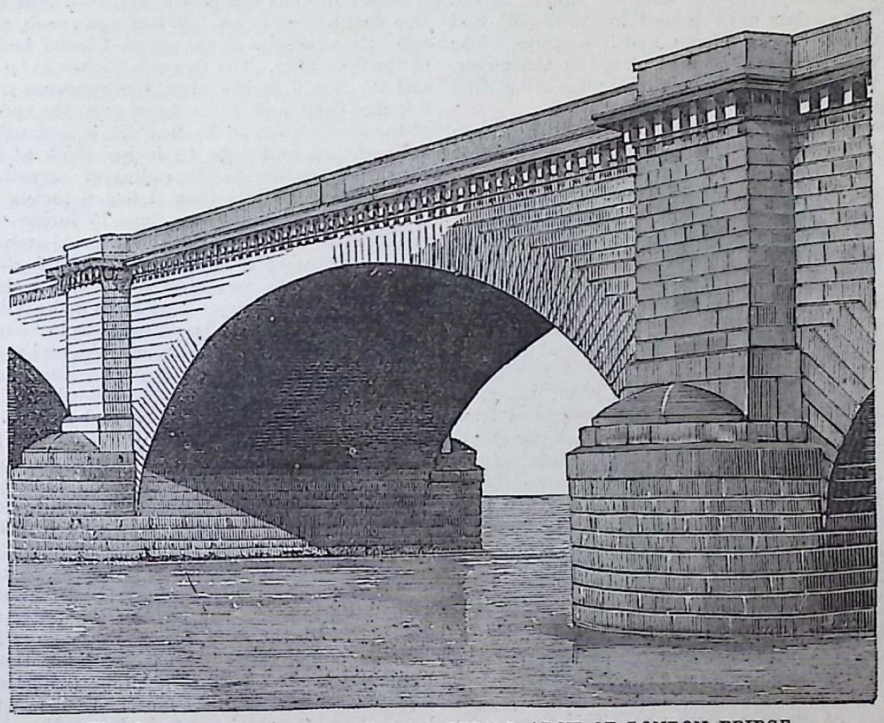


Fig. 85.—PERSPECTIVE VIEW OF A SINGLE ARCH OF LONDON BRIDGE.

With respect to the pressure which it is safe to bring to bear upon the arch-stones of a bridge, it is obvious it is a matter wholly dependent upon the character of the material. This is evident from the relative dimensions just assigned for the crown of an arch, whether consisting of stone or brick. The crushing which stone of various kinds will bear has naturally been made the subject of careful experiment. We subjoin a few facts, the result of observation:—

Description.	Crushing force in lbs. per sq. inch.
Brick	1,500
Brickwork in cement	1,000
Portland cement	1,000
Granite	8,000
Limestone	5,000 (average)
Marble	6,000
Sandstone	5,000
Portland stone	3,700
Slate	11,000

These constitute the materials usually employed in masonry.

Instances are on record of engineers having employed stone in positions where too close an approach has been made to the yielding power of the material, notably in the pier of the Chapter House at Elgin, forming a portion of the remains of the once beautiful cathedral there, but it is not a wise step. As a rule, the greater the pressure the greater should be the area over which the pressure is spread, and it is not safe to exceed one-tenth of the actual yielding-point of the stone; nevertheless,

it is a remarkable fact, as observed by Mr. Gauthey, that the strength of stone increases in a higher proportion than the surface of the base extends.

We shall close the subject of masonry bridges by some extracts from the specification of the work which was required for London Bridge.

The *coffer-dams* to be elliptical; all the piles to be whole timbers of the best Baltic fir, and not less than 12½ inches square. The main dam to have two rows of piles 5 feet apart, and not less than 5 feet above high-water mark of spring-tides when driven, connected together with three rows of double whole waleings, secured by 2-inch iron bolts at every 10 feet apart, with plates and nuts. The main dam to be surrounded by an outer row of whole timber piles 6 feet from the next inner row, connected by three rows of double whole waleings, 12½ inches square, and secured to the main dam by long wrought-iron 2-inch bolts passing through all three rows of piles at each row of waleings. The spaces between the three rows to be filled in with well-beaten clay, and the exterior joints caulked and pitched. The whole dam to be braced longitudinally and transversely with timber braces, struts, and iron straps. The dams to be fitted with three sluice-gates, placed in the upper, middle, and lower tiers of waleings. All the piles to be shod with iron, and hooped at the top.

The earth for the foundations of the abutments to be taken out to a depth of 34 feet 6 inches at the front below high-water mark, and 25 feet at the back. The earth for the two side piers to be taken out to a depth of 40 feet, and that for the remaining piers to a depth of 43 feet below high-water mark. The piles to rest the piers and abutments upon to be of elm, fir, or beech, not less than 12 inches diameter in the middle, and 20 feet long, shod with iron shoes weighing 35 lbs. each, and hooped at the top with iron hoops 30 lbs. weight each. The piles under the abutments to be driven at right angles to the inclination of the floor, and those for the piers perpendicularly, and not less than 18 feet into the solid ground, and in rows 4 feet apart from centre to centre. The heads of the piles when driven to be cut off level, and 9 inches of earth to be removed from between the heads, and the space filled with Kentish rag-stone, beaten down and mixed with sharp gravel and lime screenings, in the proportion of one of lime to five of gravel, and sills of beech, elm, or fir, 12 inches square, to be laid upon the pile-heads in a direction transverse to the foundations, and spiked down with 18-inch jagged iron spikes. The spaces between the sills—the extremities excepted—to be filled in with brickwork set in mortar, the outer spaces with square blocks of stone. Other sills to be laid across the lower ones at right angles to them, of the same material and size, and spiked down as before, the spaces to be filled in with stone set in mortar, and the whole covered with 6-inch beech, elm, or fir, bedded in mortar, well fitted, close-jointed, and spiked down with 12-inch jagged spikes three-quarters of an inch diameter. This forms the platform.

Round the three sides of the abutments, and round each pier, sheet-piling to be driven not less than 12 feet below the level of the platforms; the abutment piles to be of beech, elm, or fir, 6 inches square, and those for the piers to be of fir, 12 inches square, to be ploughed and tongued on the edges, and driven perfectly close, and connected with half timber fir waleings, bolted to the piles. The sheet-piles to be shod and hooped with iron.

Similar foundations to be prepared for the stairs by the abutments, but only one tier of sills required.

The masonry of the abutments from the platform to the springing of the arch to be built of ashlar, from 15 inches to 24 inches thick each course in front, and the beds to incline backwards parallel to the inclination of the platform. The exterior stones to be of granite to within 3 feet of the springing of the arch, the interior stone to be half Bramley Fall, and the remainder Painshaw, or equally good. The masonry to be formed of headers and stretchers alternately; the headers to average 5½ feet long and 3 feet wide, but none to be less than 4½ feet by 2 feet 3 inches. The stretchers to average 5 feet long and 3 feet wide, but none to be less than 4 feet by 2 feet 3 inches.

The backing to be laid in courses of headers and stretchers alternately, the headers being opposite to the stretchers in front, and of a suitable size, so that the whole of the masonry, both exterior and interior, shall be completely solid and bonded together, and double joggles to be used where required; the upper bed of each course to be dressed off smooth and even before the next course is laid. The whole of the exterior stone to be smooth, and fine hammer-dressed on the face.

The masonry of the piers up to the course next to the springing of the arches to be built of ashlar in horizontal courses from 15 inches to 25 inches thick. The exterior stone for 5½ feet inwards to be of granite, the interior the same as in the abutments; the arrangement of the masonry to be the same also.

Four sets of centres are required, each centre to consist of eight ribs properly braced together; to be composed of the best Baltic fir, except the springing pieces, which are to be of elm, and the striking wedges of oak, cased with copper one-tenth of an inch thick on the upper and lower sides, and greased before put into their places.

The arches to be semi-ellipses, the centre arch 152 feet span in the clear, and 29 feet 6 inches rise; the voussoirs to be 4 feet 9 inches deep at the crown, and 10 feet at the springing. The two next arches to be 140 feet span each, and 27 feet 6 inches rise; the voussoirs at the crown 4 feet 7 inches deep, and 9 feet at the springing. The two side arches to be 130 feet span each, and 24 feet 6 inches rise; the voussoirs at the crown 4 feet 6 inches deep, and 8 feet 6 inches at the springing. The whole of the arch-stones to be headers, except otherwise allowed by the engineer, and to be 18 inches thick at the intrados, and to increase according to the radius of curvature to the extrados, and none to be less than 2 feet 6 inches wide, and none to overlap at the joints less than 15 inches. The length of the voussoirs to increase when the inverted arches on the piers commence, according to drawing. The arch-stones to be dressed perfectly smooth and straight on the beds, sides, and faces, without any deficiency. The faces and soffits to be fine-dressed as before described. The extrados to be rough hammer-dressed, except when the inverted arches join, and there smooth-dressed, so as to bear solidly in every part. The whole of the arches to be of the best granite, properly bedded and jointed in mortar.

The spandrils over the piers to be of solid masonry in horizontal courses, corresponding in thickness to the back part of the arch-stones at their respective places, and to be of granite.

The inverted arches over the piers to rest on the solid spandrils, and accurately fitted to them, and to be 6 feet deep in the middle for the two centre piers, and 5 feet deep for the two side piers, and to be of the best granite, and set in fine mortar. A circular opening, 18 inches diameter, to be left through the centre of each pier, and through the solid spandril and inverted arch, down to below the level of low-water mark, and to communicate with the river, for the drainage of the roadway.

The spandril walls to be 5 feet thick, the courses to be laid headers and stretchers alternately, the headers not less than 2 feet 6 inches wide in the face, and not less than 3 feet 6 inches long. The stretchers not to be longer than 5 feet, nor less than 2 feet 6 inches broad on an average. The cap-stones on the point of the piers to be secured to the facia course below by 6-inch square stone dowels of the best granite.

A rectangular buttress is to be built over each pier and abutment, the outside to be faced with granite, and to extend to a depth inwards of at least 3 feet 6 inches; the faces, beds, and joints to be properly dressed and secured to the course below with stone dowels.

The outside of the abutments and wing-walls above the springing of the arches to be faced with granite, and to be not less than 3 feet 6 inches deep on an average.

The whole of the joints on the back of the arches and inverted arches to be well cleared out, and any opening found to be filled with grout, and afterwards pointed with Roman cement, and the whole surface of the arches between the termination of the inner spandril walls on each side of the crown of the arches to be covered with a coating of Roman cement of the best quality. The interior spandril walls to be of the best well-burnt grey stock bricks, laid flush in mortar consisting of three parts sharp river sand to one part of well-burnt lime; the interior mortar to consist of four parts sand to one part lime. These walls to be six in number over each pier, and to extend from arch to arch, and to be 2 feet 3 inches thick. On the top are to be stone corbels 18 inches deep, projecting over not less than 12 inches.

The arches and spandril walls being brought up to the level of

the roadway, the whole surface of the bridge is to be covered with a bed of sound, tough, well-beaten clay, 15 inches thick, so as to be perfectly impervious to water. Over the clay is to be 3 inches of fine sand, then 12 inches of fine flint stones, no stone to be larger than 2 inches in diameter, and the whole to be rolled. The foot pavement to be of granite stones, 7 feet 6 inches long, 8 inches thick, and 3 feet or upwards wide, one end to be bedded on the cornice, the other end to be supported on curb-stones not less than 4 feet long, 9 inches wide, and 12 inches deep, set edgeways, of the best granite, properly jointed and set in mortar, the intermediate spaces to be filled with fine gravel or sand. Along the front of the curb-stones are to be gutters paved with granite pitching paving, 9 inches deep for a width of 5 feet 6 inches from the outside of the foot paving. The roadway is to be curved 6 inches in its transverse direction, and the clay and pavement is to incline towards the gutters.

The cornice and parapet to be of the best granite, finely dressed and jointed; none of the stones to be less than 4 feet 6 inches long, bonded and dowelled. The coping to be dowelled at every joint by a projecting dowel, 2 inches square, fitted into an equal recess in the adjacent stone.

The approaches to be formed of solid embankments and arches where the height will admit; the former to be supported on the sides with brick retaining walls, and the piers of the latter to be founded 6 feet below high-water mark, the retaining walls to be 3 feet below this mark. The arches to be semi-circular, 16 feet span, and 18 inches deep at the crown.

The contract concludes with a most elaborate and carefully drawn covenant between the committee and the contractors.

In Fig. 85 we present a perspective view of one of the arches of this magnificent bridge, which was commenced on the 15th of March, 1824, and opened to the public on the 1st of August, 1831. The bridge contains 120,000 tons of stone, and rests upon 2,092 piles, 20 feet long. The total cost, including the contractor's estimate, the purchase of land, compensations, and law expenses, was £1,458,311 8s. 11¾d.

OPTICAL INSTRUMENTS.—XXVII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

THE MODERN SYSTEMS OF MAGIC-LANTERN APPARATUS.

HAVING described the best methods of constructing the various elements of the magic lantern, I proceed to show the arrangement of the entire instrument under its various modifications of form to meet the special requirements of the school-room, the lecture-theatre, and dioramic exhibition.

The School System.—It is very important that the schoolmaster should be provided with an efficient instrument, that could be brought into immediate use for the exhibition of geographical and historical illustrations, and should occupy the least possible space when not in actual service. Such an arrangement is shown in Fig. 133, arranged for work, with its slide-tray in front. The body is made of japanned tin in an L-shaped form, to allow of its square chimney being packed away inside the body. The source of light is the hydrocarbon lamp of the form shown in Fig. 88, page 324, Vol. III. of THE TECHNICAL EDUCATOR, supported on the clamp-rod and sliding-floor shown in Figs. 110 and 111 of Vol. IV. As this lantern is intended for the exhibition of photographs by a weak light, my optical part consists of *a short-focussed condenser* and a *single* achromatic combination power, as a double combination portrait-lens (so useful for lime-light lanterns) absorbs too much light when Argand burners (weak lights) are employed; and with this arrangement I get a well-defined, flat, and brilliantly lighted picture up to 10 feet in diameter. The optical elements are fitted over the projecting limb of the body.

The slide-tray consists of three compartments, 3½ inches "full" square, each being deep enough to hold twenty-five photographic lantern-slides. The sides of these compartments are open, to allow of the finger and thumb seizing the slides. One compartment is left vacant, to allow of the arrangement being used in the following manner:—*The frame* is tunnelled and long enough to hold three slides in a row; in the centre portion there is a 3-inch circular aperture, which corresponds with the axis of the optical parts. One slide is pushed in, then a second, to bring No. 1 central; when this has been shown, a third is inserted, which brings No. 2 central, and No. 1 to the opposite end of the frame; this is now removed and placed in the vacant compartment of the slide-tray; when twenty-five slides have been shown, the empty compartment has been filled up, and the middle one emptied. In the same way this receives the slides as used from the last compartment; and when all have been shown a cover is dropped over to pack and protect them from meddlesome hands. The slide-frame was contrived by Mr. J. T. Taylor; the slide-tray is an arrangement of my own, being a modification of my slide cabinet, presently described. The slide-tray packs inside the square chimney, and as this again packs inside the body of the lantern, the whole may be packed into a box which only measures 13 inches long by 9 inches wide, and 9 inches high. The lid of the box is hinged, and by means of two notched rods may be set at any angle, so as to allow of the box being used as a stand, should it be necessary to "cock the lantern" to get it adjusted to the screen.

The screen is made of seamless cotton surfaced with flexible whitewash, which presents a perfectly opaque white ground, admirably adapted for showing lantern views in the most perfect manner; this is mounted in a case after the manner of a wall-map, so that it can be pulled down or up out of the way in a moment. The lamp may be made to occupy a permanent place for illuminating the master's desk for ordinary use in a school-room, and the lantern may be fitted and the screen

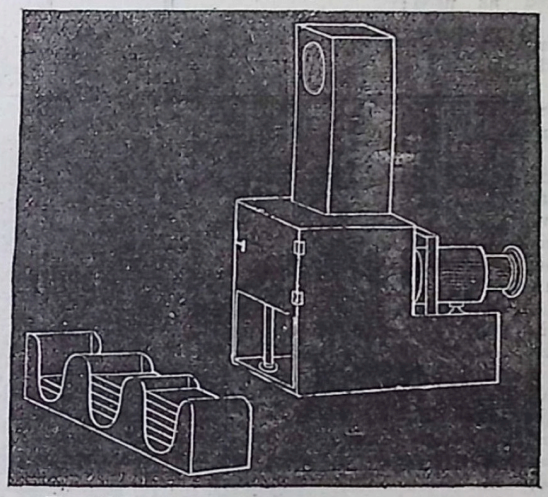


Fig. 133.—SCHOOL LANTERN AND SLIDE-TRAY.

pulled down when wanted in less than five minutes. In such case the desk should be placed at such a distance from the wall that the disc of light from the lantern just fills the screen.

The Photographer's System is similar to the lantern just described, but the stage, front tube, and power are removable, and may be used as a tubular metal camera for taking the negatives from which to produce transparent positives for our lantern exhibitions. It is then fitted with three double backs and a focussing glass, together with a table-top that folds to the same size as the back, which allows of the photographer taking stereoscopic as well as single views. The size of the negatives are circles 3 inches in diameter, on glasses 3½ square. This camera, with its appliances, packs into a small leather case, and with a folding or alpenstock tripod forms a very convenient travelling companion. This lantern can be fitted with a single stereoscopic lens for the Argand burner, or a quarter-plate lens if the oxy-spirit, oxy-house-gas, or oxy-hydrogen jets, or the magnesium lamps previously described, are to be used for producing transparent positives for the lantern, or enlargements on paper.

The Demonstrating System.—This lantern consists of a well-seasoned mahogany body* fitted with a flat dome of japanned tin, the convertible jet described and figured at pages 188 and 189, Vol. III. of THE TECHNICAL EDUCATOR, and a short-

* The oldest material attainable—preferably old dining-table tops, showy pattern in the wood being rather objectionable than otherwise.

focussed condenser, double achromatic combination, that is separable for a long-focussed arrangement, mounted to the stage, as shown in Fig. 130, page 334. This lantern is shown mounted on a lecture-room stand, which admits of every possible adjustment for optical demonstrations, in Fig. 134. It may be mounted single or in pairs for dissolving views, as shown in Fig. 135, where the slide cabinet and the packing-case form the stand; or if required for the electric light it may be mounted on a gallery supported on four brass pillars, as shown in Fig. 136, to allow of the tall regulator being adjusted within it.

The Slide Cabinet.—This I have arranged with the view of keeping all the slides required for any given lecture in methodical order; further, that a wrong slide can never be taken by mistake while working in a darkened room; that the slides should be repacked as used; that they could never be exposed to meddlesome hands, and could be put under lock and key the moment a lecture is over. The arrangement is simple, and the working will be readily understood by aid of the annexed diagram (Fig. 137). The cabinet is divided into three compartments, and is fitted with two hinged doors, A and B, and two sliding panels, C and D; the compartments 1 and 3 are closed, with fixed ends E and F. Compartments 2 and 3 are filled with framed slides measuring 7 by 4½ in., arranged in order ready for use. In commencing, the doors A and B are turned back so as to display the first pile of slides in 2, and the empty compartment 1. The top slide is taken off the pile in 2, put in the stage by the exhibitor standing on the right-hand side of the lantern, and is withdrawn by his assistant on the left-hand side, who places it in the empty compartment 1, and so on. When all the slides in 2 have been shown, that compartment will of course be empty, and 1 full. The sliding panel C is then drawn back to expose the second pile of slides in 3, and D is drawn back to make a receptacle for the slides as they are passed through the lantern from the compartment 3. It will be seen that the piles of slides can never be knocked over, as each compartment must always be backed, and it is impossible to take a slide from the wrong pile. At the end of a lecture the panels are drawn back and the doors closed. On the following day, it is only necessary to return the slides in reverse order to their original compartments, and all is ready for the next lecture. This arrangement was described and exhibited at my second lecture before the Society of Arts, and, with my entire "system of apparatus," received the honour of admission to the Educational Department of the International Exhibition of 1870.

If the lantern is used with a 7-foot screen, the cabinet placed on the packing-case raises it so that the nozzle is central with the screen. If used with a 10-foot screen, then the cabinet is raised on a shell frame, that is made to pack outside the cabinet, as shown in Fig. 135, the nozzle in this case being also brought central with the screen. Both lantern, slide cabinet, and its shell pack away in a box 18 by 16 inches and 18 inches high.

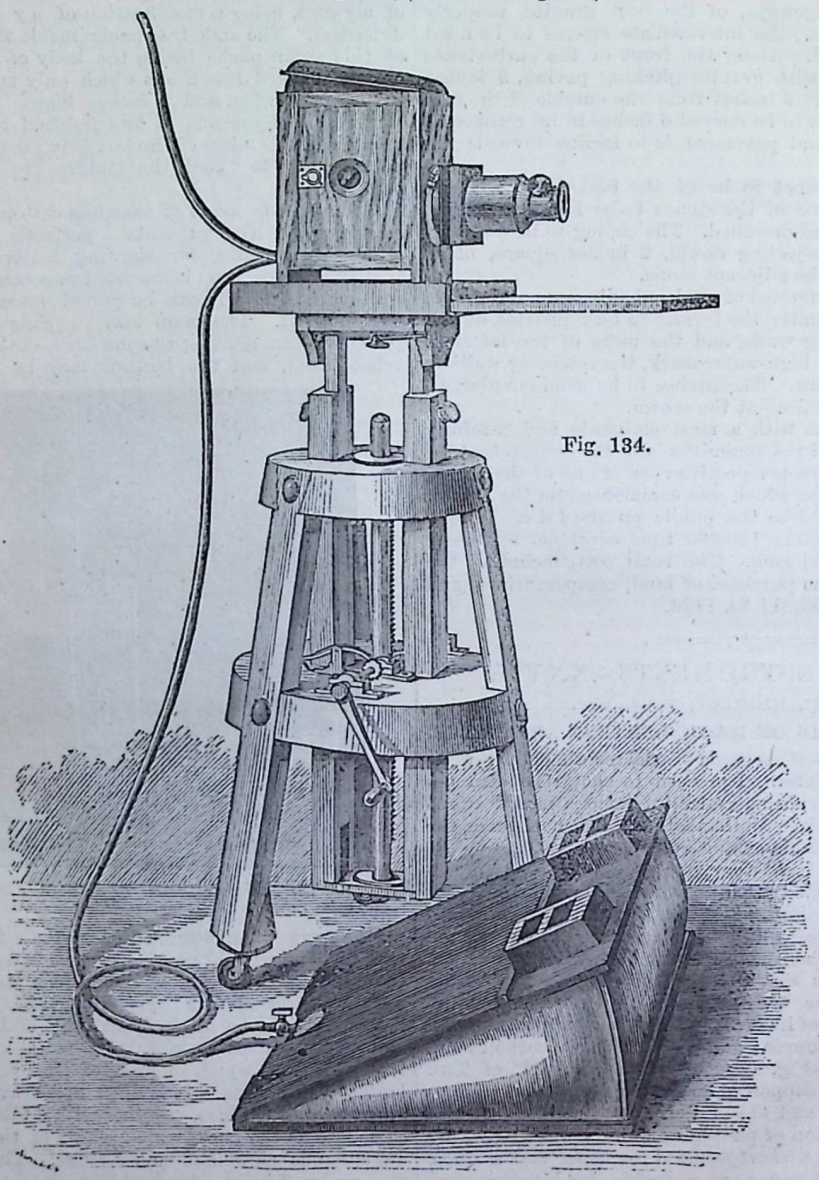


Fig. 134.

Portable Drawing-room Screen.—This is also made of seamless cotton with an opaque white surface; it is 7½ feet square, mounted on a lath and roller which stows into a packing-case 8 feet long by 5 inches square, as shown in Fig. 138. Beneath this case two pieces, that together correspond with its length and breadth, are pivoted so that they can be turned at right angles to the case, and so form a firm base on which to fix in sockets two uprights, on which the lath is clamped, and then the screen is unrolled, as shown in Fig. 139. This can be unpacked and packed in a few minutes, placed in any convenient position at the moment wanted, and removed out of the way as soon as done with—a matter of importance for drawing-room exhibitions, as it dispenses with the removal of wall-pictures, furniture, etc. The height just allows of the frame being fitted together conveniently when the operator stands upon a chair.

Portable Lecture-room Screen.—This is 10 feet square, the largest size of *seamless* cotton attainable; it is mounted on a lath and roller, which slides into a long tubular case. To raise it against a wall, two long struts are provided, which for the sake of portability are hinged at their centres, but can be made rigid when placed at full length by means of bolts. The ends are cut at an angle, so as to fit wall and floor; when each strut is inclined against a wall, the lower ends are fixed to the floor by "stage screws" fitting in slots, the upper ends are fitted with small pulley-wheels, and the screen is pulled up by cords passing over them. These struts pack into a small case.

It will be observed that every provision is made in this *Demonstrating System*, not only for all the necessary apparatus being packed in the smallest possible compass for the con-

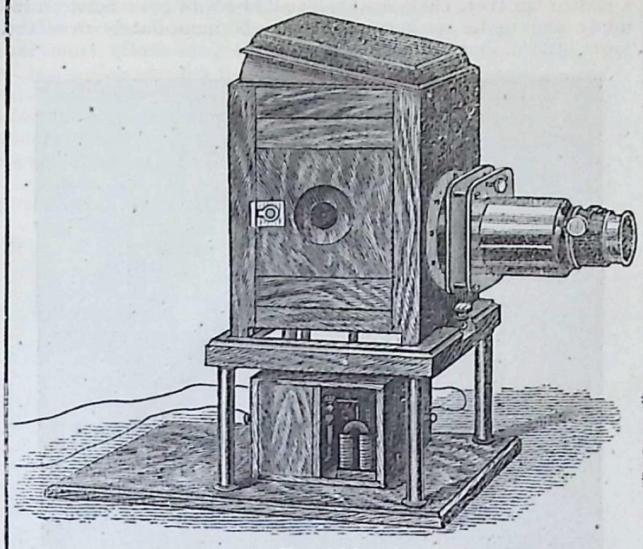


Fig. 136.

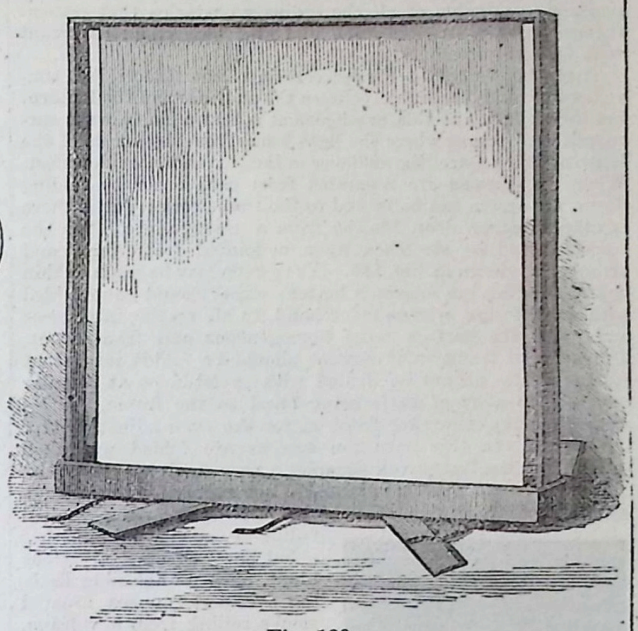


Fig. 139.

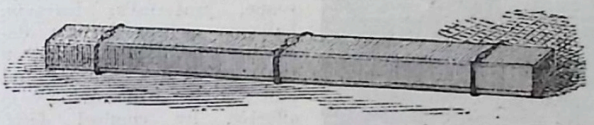


Fig. 138.

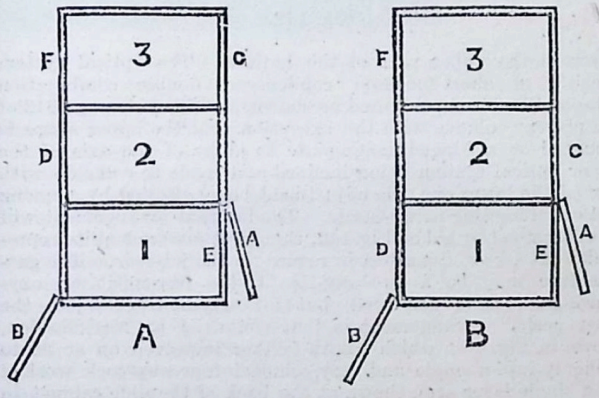


Fig. 137.

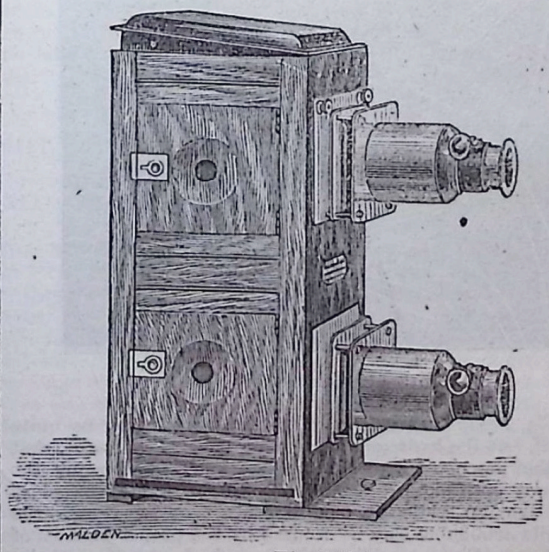


Fig. 141.

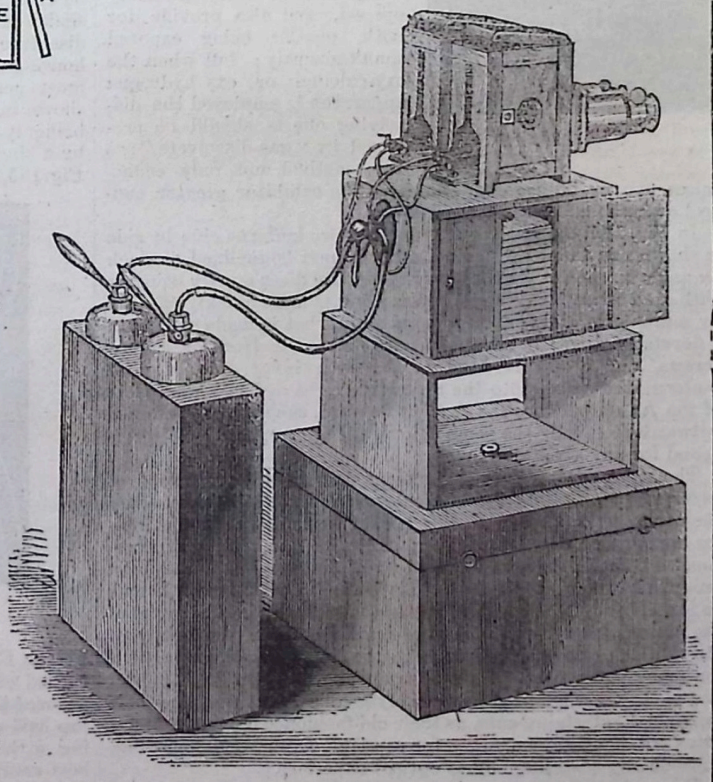


Fig. 135.

venience of travelling lecturers, but also to render them as independent as possible of all the ordinary obstacles that present themselves in a strange place, and with persons unconversant with their requirements.

Transparent Screen.—Under certain circumstances it is convenient to place the screen *between* the audience and the lantern, but the objection to this arrangement is that a halo always surrounds the opening where the light issues from the nozzle of the lantern, which stares the audience in the face and mars the effect. Where two rooms are separated from each other by folding doors, the screen can be tacked to the framework; but if there is only a narrow door, leading from a passage, etc., then the screen should be stretched upon a jointed framework, and arranged as shown in Fig. 140. The screen may be made of thin cotton sheeting, but muslin is better: either should be sprinkled with water from a syringe beforehand, to fill up the interstices and make the surface more homogeneous and transparent. The sides of transparent screens should be folded into stout seams, which should be drilled with eyelet-holes at regular intervals, to allow of their being *laced* to the frame, as this method admits of greater freedom for the even adjustment of the surface. In this case the screens are folded up, when packed, and the framework occupies a very small space.

The Dioramic System is intended not merely for the production of what are termed *dissolving views*—that is, the gradual fading of one view into another—but fine "effects" of various kinds, such as lightning flashing over a stormy sea, fire and smoke rolling from a volcano, burning buildings, etc.; snow falling over a winter landscape, waterfalls, torrents, balloons rising, demons descending, animals springing on their prey, etc. In Argand lanterns the "dissolving" is effected by combed fans, which, by various mechanical arrangements, obscure one nozzle as the other is gradually opened, and also provide for both nozzles being exposed simultaneously; but when the oxy-calcium or oxy-hydrogen apparatus is employed the dissolving effects should be produced by "gas-dissolvers," as this method not only economises one or both gases, but gives the exhibitor greater control over the effect thereby produced.

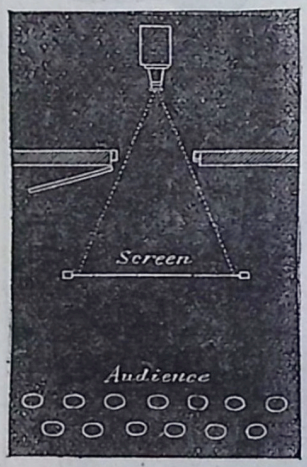


Fig. 140.

In Fig. 135, the method of arranging two lanterns side by side is shown; in this case the two nozzles must be inclined at such an angle to each other that their respective discs *exactly* coincide with each other. This adjustment, I find, is more quickly effected by means of ∧ slots cut in a brass plate, that is made to slide in a dovetail fitting; both lanterns are pivoted in front on clamp-screws, and a pin is fixed to the back inner side of each lantern; these drop into the respective right and left hand slots of the ∧; on pushing the ∧ slots forward, each lantern is forced outwards to exactly the same extent, till their optical axes correspond for any given distance.

The most convenient arrangement is that where, instead of two lanterns, the jets and optical systems are placed one over the other, as it is the only arrangement that allows of the exhibitor managing a dioramic lantern single-handed. This arrangement is sometimes termed the *bi-unial lantern*, but it has been brought to the greatest state of perfection in what is now known as the *Highley-Malden dioramic lantern*, as the improvement of the lantern for an educational weapon has been the hobby of Mr. Malden (travelling lecturer to the Polytechnic) and myself for many years past. This instrument is shown in Fig. 141, and is that now adopted at the Polytechnic Institution for their provincial entertainments, as their old-fashioned cumbrous apparatus entailed heavy charges for carriage, fixing, and removing, without any advantage as to optical superiority.

It consists of a mahogany body fitted with flat dome, a pair of "convertible jets" mounted on "clamp rods," the lower rod being attached to a sliding wooden slab, the upper rod to a sliding tin tray, made double to allow air to pass between its upper and under surface (as it stands immediately over the lower jet), and narrow to allow air to pass freely from the

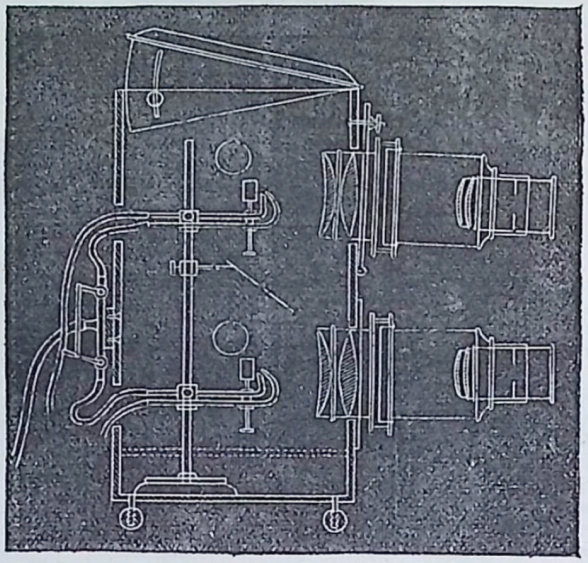


Fig. 142.

lower to the upper part of the lantern. The optical system consists of short-focussed condensers, double combination achromatic powers, mounted as shown at Fig. 121, page 312 of the present volume, with the exception that the upper stage is mounted on a hinged flange-plate to allow of the axis of the upper optical system being inclined and made to coincide with that of the lower one, the adjustment being effected by a spring and counteracting screw-heads. The internal arrangement will be understood by aid of Fig. 142, though it does not quite represent what I have described in regard to the jet-rods. The gas-dissolver may be a two-way-tap if the oxy-spirit or oxy-house-gas jet is employed, but for oxy-hydrogen jets the most perfect arrangement is that contrived by Mr. Malden, shown in Fig. 143, which I have further improved on so as to bring it into a single and very compact four-way-cock worked by a single lever arm, shown at the back of the slide cabinet in Fig. 135, but which does not convey the notion of construction so

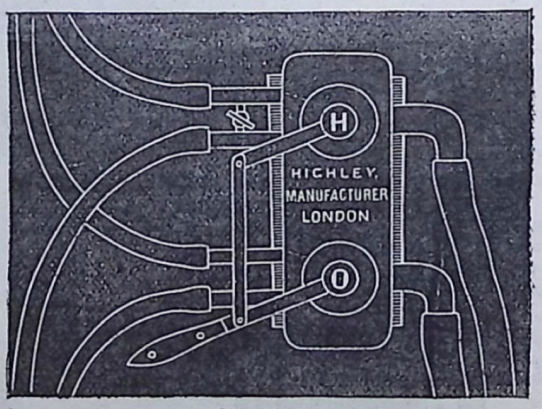


Fig. 143.

well as Fig. 143. On turning the tap the oxygen may be quite turned off, but the hydrogen is only cut down to a point, that ensures that gas being kept constantly alight. By turning the tap half-way both pictures are equally illuminated, or by playing with the tap while the exhibitor observes the screen, the best results attainable may be secured by the proper balance of light between the two slides, when producing "effects" by super-position; as in the case of *bright* smoke on a *dark* view,

in the subject of the "Steamer leaving the port of Alexandria." The hydrogen is admitted by the upper large tube, and is then divided by the tap H (Fig. 143), from whence it is carried by short flexible tubes to the hydrogen tap of each jet, the balance of gas being effected by the small tap placed between the two exit-pipes. The oxygen is admitted by the lower large tube, and is divided by the tap O, both taps being made to work in unison by the connecting bar and lever-arm. This arrangement also entails a considerable saving of both gases.

Flashing fans are arranged so as to *instantly* cut off one picture and throw another on to the screen, as, for instance, when a tiger is depicted *about* to spring upon its pursuers in one view, and *then* on the body of its victim in the next. An "effect" is then said to be "flashed on." It is very advantageous to employ a third lantern when "effects" are to be produced in public, and in such cases it should be of the true *phantasmagoria* construction, that is to say, it should be made to run on a tramway to and from the screen, and simultaneously, by means of a lever and roller working on an inclined bar between the trams, not only automatically adjust the focus, but also reduce or enlarge the aperture of an "iris diaphragm" placed in front of the power, shown in Fig. 144, which opens or shuts by the upward push or downward drag of the two rods; as otherwise the picture would be too intensely brilliant at the very moment it ought to be of an opposite character—that is to say, when a figure is supposed to appear at a great distance off because it is of small size, when consequently the lantern must be near to the screen, and, according to the law of inverse square, the illumination at its brightest. The reverse, of course, obtains when the object appears to be near to the spectator, because larger, and the light is then most distributed over the screen because the lantern is withdrawn from it.

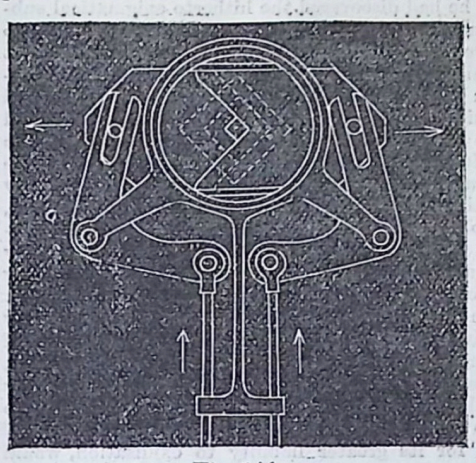


Fig. 144.

In concluding this series of articles on "Optical Instruments," I may state that I have selected those subjects which are not fully treated on in a technical manner according to the latest experiences in existing works, rather than compile matter which may be found in English or foreign books on optics.

NOTABLE INVENTIONS AND INVENTORS.

BY JOHN TIMBS.

XLI.—THE EARL OF ROSSE, K.P., F.R.S.—GREAT REFLECTING TELESCOPES (*continued*).

THE magnificent instrument described in our preceding paper rendered valuable services to astronomy by the light which it threw upon the structure of the nebular part of the universe. It was about Christmas, 1845, that the great six-feet reflector was first directed to the wonderful nebula in Orion; and who shall tell the anxiety with which the result of that gaze was watched? Did nebulous fluid exist in space or not? That was the question to be solved. And solved it was. That fleecy cloud was *not* a vapour; it consisted of stars! Worlds, millions upon millions—who shall say not peopled with intelligent existences? This gigantic telescope is, as compared with the human eye, as 130,000 to 1; it has a penetrating power of 500; and can render visible stars whose light would require 60,000 years to reach the earth!

Many nebulæ, which had hitherto resisted all attempts to resolve them with instruments of inferior power, have been found to consist wholly of stars. Others exhibit peculiarities of structure wholly unexpected. Thus, former observers suggested the probability of the nebula No. 51 in Messier's catalogue being a vast sidereal system, identical in structure with a smaller one in its immediate vicinity, and to which it offered a striking analogy. The telescope of Lord Rosse has, however, destroyed this interesting surmise, by showing the nebula to be of a totally different structure—to be, in fact, composed of a series of spiral convolutions, arranged with remarkable regularity; and a connection has also been traced, by means of these spirals, between the nebula and its companion.

In 1862 Lord Rosse communicated to the Royal Society further observations upon the nebulæ, with practical details relating to the construction of large telescopes. These are followed by a selection from the observations made during a period of six years, accompanied by drawings of the more remarkable objects. The principal results seem to be a large addition to the list of nebulæ with curved and spiral branches, and many new double and multiple nebulæ. A variety of objects have also been pointed out upon which the labour of a careful scrutiny will probably be amply repaid, with a similar instrument, even in this climate.

Spectral analysis has been used by our countrymen to scrutinise not only planets and stars, but even to reveal the constitution of the nebulæ, those mysterious masses out of which it has been thought that new suns and planets might be evolved—nursing mothers of the stars. For a time, indeed, the resolution of the nebulæ by the giant mirror of Lord Rosse afforded ground for opposing the speculation of Herschel and the reasoning of Laplace, which required for their very starting-point the admission of the existence of their gaseous expansions, with or without points, or centres of incipient condensation, with or without marks of internal movement. The results of the spectral analysis of stars have, however, restored the balance. The nebulæ are, indeed, in some instances, found to have stellar points; but they are not stars. The whole resembles an enormous mass of luminous gas, with an interrupted spectrum of three lines, probably agreeing with nitrogen, hydrogen, and a substance at present unknown. (Professor John Phillips, F.R.S.)

A question, however, arises as to whether Mr. Huggins's discovery by the spectroscope really overthrew the hypothesis of Dr. Herschel. It would appear not. Dr. Herschel found some of the nebulæ to consist of clusters of telescopic stars, and others (among them the nebula of Orion) appeared as mere luminous spots, or cloudy masses of vapour, of different forms, which it was considered might be gaseous matter in the process of formation into suns and their attendant planets. Herschel was of opinion that these luminous spots, when viewed through glasses of higher powers, would be resolvable into masses of nebulous stars of countless numbers. Lord Rosse subsequently examined Orion with his powerful telescope, and found the nebula *resolvable*, and thus the hypothesis of Herschel was *à fortiori* confirmed and *de facto* established. In using the term "stars," Herschel doubtless intended it to be accepted in the general sense—viz., luminous bodies—and not as commonly used by English writers to denote fixed stars of the usual density. If we assume this to be the definition of the term used, we shall find that the recent discoveries of Mr. Huggins not only do not refute, but actually confirm the assertion made by Lord Rosse, the investigations of Mr. Huggins having, as already stated, proved the nebulæ to be masses of incandescent gas, or, in other words, dense clusters of luminous cloudy bodies, or gaseous stars. ("The World of Wonders," Correspondence, p. 34.)

Investigations into the nature of the nebulæ have tended to confirm the accuracy of the views of Laplace, who held that the sun and planets were formed out of a great nebula, which by condensation separated into rings, and these rings finally collapsed into stars. The zodiacal light is supposed to be the remains of the great nebula out of which the solar system was constructed, and the condensed matter rained into the sun, and there burnt, is supposed to be the origin of the sun's light and heat. One question, however, still remains unsolved. In what way did the nebulæ originate? Is each nebulous atom formed out of the other by the action of light, and the aggregation of still minuter particles, in the same way in which a nebula, by its condensation, goes to form a planetary system?

We are induced, by way of summary, to pursue the subject

still further, as illustrated with peculiar force in the *Saturday Review*, in a paper wherein the negative results are somewhat strongly designated as "the *break down* of the nebular hypothesis, under the disclosure of Rosse's telescope—a remarkable instance of a promising speculation prematurely cut short." It is explained as follows by Sir Henry Holland (President of the Royal Institution):—

"The third great result from Lord Rosse's telescope—viz., the resolution into stars of many nebulæ before unresolved—bears closely on the question so much agitated of late, as to the existence of a self-luminous nebular matter diffused in different parts of space, and forming the material out of which worlds are aggregated and systems of stars are brought into being. This theory, sanctioned by eminent names, and plausible at least in its application to our own planetary system, found support in the aspect of such unresolved nebulous lights in the remote heavens. The simple fact that the progressive increase of telescopic power has, in the same ratio, disclosed to us these luminous masses as clusters of innumerable stars, must be considered a cogent, though not a decisive, argument against it; the nebulæ still not analysed presenting the same aspect as those which have been thus recently resolved, and perhaps awaiting only a higher power to afford the same results. Furthermore, it may reasonably be doubted whether nebulous matter, yet uncondensed into stars, could from distances such as these radiate light apparently equal in intensity to that of nebulæ known to be composed entirely of stars. The whole question, by the very terms of it, will be felt as one incapable at present of any complete solution. But the negative, upon the modern nebular theory, has been strengthened, and those bold speculations placed in abeyance which dealt with the consolidation of worlds as if it were a matter of familiar observation, and within the compass and calculation of ordinary science. We acknowledge ourselves of the number of those who hold this to be a salutary check, and in accordance with the true interests and legitimate course of physical inquiry."

A new difficulty has, however, arisen from these vast successes in telescopic construction. To ensure the best performances of a telescope, not only should there be a cloudless sky, but a perfectly quiescent state of the whole atmosphere—a most serene and quiet air, and this is indispensable for high magnifying powers; yet so rarely is this state of the air to be found at the sea-level, that Lord Rosse assures us that whole years have passed away without affording him, among an abundance of clear nights, one of such accurately defining quality as to enable him to use the higher magnifying powers of his great reflecting telescope to any advantage. And this is a difficulty which continually increases with the size and excellence of the telescopes employed.

The Earl of Rosse, the framer of the great reflecting telescope, died at Birr Castle, on the 31st of October, 1867. Within a period of ten days died Sir James South, another celebrated worker in the same direction; and Lord Wrottesley, whose high astronomical attainments are also well known.

GREAT MANUFACTURES OF LITTLE THINGS.—XVII.

SMALL PLATED WARES AND ELECTRO-PLATING.

BY CHARLES HIBBS.

About the middle of the last century, the miners who worked in the silver and copper mines of Germany came upon a vein of glittering ore, different from anything they had previously observed, having all the brilliancy of silver, with a reddish tinge that seemed to betoken the presence of a yet more precious metal. As the lode was gradually laid open, the quantity seemed abundant enough to confer inexhaustible wealth upon the fortunate finders, and they gave themselves up to the wildest excitement at their good luck. Great was their disappointment to find that their new mineral treasure, so far from yielding virgin silver or gold in boundless profusion in the smelting furnace, only mocked their hopes by giving up, after innumerable trials and experiments, a nasty, brittle substance of a dirty-white colour, that went to dust under the hammer, and which the crucible would only reduce to a miserable grey ash. Thus baffled of their El Dorado, the miners, superstitious from time immemorial, easily came to think that some *diablerie* was at work, and whenever they found the villainous ore, bestowed upon it, along with their most supreme contempt, a name by which they had been used to distinguish the gnome or goblin of the mine, to whose evil influence they attributed this and all other of their misfortunes. Thus, the new metal came to be called "nickel"—*Anglicè*, "Old Nick—" and for a long time only turned up to be thrown aside with grudging toil and bitter disgust. At last, the celebrated Swedish chemist and mineralogist, Kronstadt, hearing of it, obtained some specimens which had been found in the mines of Helsingland, and subjected them to analysis. After five years of laborious investigation, he announced that he had discovered the hitherto enigmatical substance to be one of the elemental forms of matter, not capable of being resolved into any constituent parts, and classed it among the semi-metals. Thus heralded, it attracted the attention of men of science in various countries, who bestowed upon it an infinite degree of learned labour and research, all to no purpose. Richter, of Berlin, succeeded in reducing it to a state of chemical purity, but none could master its invincible repugnance to fusion, and its use in the arts was consequently out of the question. Not until the year 1827, or thereabouts, was it turned to any useful purpose, and then a German manufacturer, named Geitner, produced, after many trials, an alloy of nickel, zinc, and copper, beautifully white, and workable by the ordinary processes, to which he gave the name of *argentan*. Since then, the same three substances have been variously mingled, and given to the world under the different names of white copper, new silver, semi-argent, albata, German silver, and many others, the last quoted being that by which the alloy is most generally known. It bears a close resemblance to silver, is fine in texture, hard, and capable of a high degree of polish, and but for its greater liability to oxidisation, would serve most of the purposes of silver equally well. For plating purposes, however, it is the very best material now known, especially *electro*-plating, for which it furnishes an excellent base; and by its similarity of colour, conceals for a longer time than copper the effects of wear and tear upon its coat. The best quality of German silver is composed of forty parts of copper, and twenty parts each of zinc and nickel; and of this alloy, so lately introduced to the metallurgical arts, there are annually consumed from 1,200 to 1,500 tons. About 7,000 persons are employed in the German silver and plated trades in Birmingham, and about 5,000 in Sheffield.

As though to rebuke the self-complacency of this age of invention, it seldom happens that any new discovery is made and turned to account, without it afterwards appearing that the same thing was known to some semi-barbarous people of remote antiquity. The Chinese have more than once forestalled us in this manner, and it was destined that they should also steal a march upon us of several ages in this matter of the new white metal. Travellers who had penetrated the Flowery Land reported that they had seen gongs and other musical instruments native to the people, made of a metal closely resembling silver, but harder, and having peculiarly sonorous properties. They added that the composition of this metal was kept a profound secret, and that it was forbidden to export it under the severest penalties. It was called *packfong*, and for a long time all that was known of it in Europe was its curious name. At last, some small articles made of it found their way here as curiosities, and got into the hands of the scientific metallurgists, who soon penetrated its mystery. Dr. Fyfe, of Edinburgh, announced that upon analysis he had found its constituents to be—zinc 25·4, copper 40·4, nickel 31·9. In short, *packfong* was no other than German silver.

It is well known that when the introduction of the voltaic process caused a complete revolution in the plated trades, the genius of Elkington was the first to seize the opportunity, and carry it to an almost unparalleled commercial success. This success has been greatly due to the fact, that from the first he determined to use the new metal, German silver, in preference to copper, for the material of his wares. The difficulties he had to surmount cannot be easily estimated by those who are not familiar with the subject. In addition to the numerous vexatious and baffling disappointments of the first stages of electro-plating, the capricious behaviour of the silver, which would sometimes only adhere in places, or not at all; sometimes lie on the work in the form of loose grey powder; sometimes come out brown, yellow, or piebald; sometimes appear covered with streaks and

nodules in most eccentric fashion; sometimes blister up and peel off altogether at the first touch of the burnisher, when an apparently firm and even coating had been, after infinite trouble, obtained: in addition to these, there were the difficulties of working the new metal, uncertain in its quality, strange to the artificer, and much less tractable at its best than the metal he had been accustomed to manipulate. It was extremely difficult at first to obtain a fixed quality of German silver. The three metals of which it was composed had each varying properties, and often contained foreign substances, which it was difficult to get rid of, such as lead, arsenic, or antimony, causing brittleness, and spoiling the colour. The nickel it was almost impossible to get pure, until a new method of refining it was discovered by Mr. Askin, a veterinary surgeon, and a student of chemistry. He was led to adopt a purely chemical method, instead of the ordeal by fire then in vogue. Mr. Askin dissolved the crude metal in acids, and precipitated the baser metals, so that the pure nickel was in a state of solution, afterwards to be precipitated in the form of oxide. The purest quality is essential for all three metals, in order to get a good malleable German silver, and even then, the inherent brittleness of the most important ingredient, the nickel, will often show itself at some critical stage of the manufacture in the shape of an ugly crack. Difficulties, however, only served to whet the resolves of the Messrs. Elkington, and in spite of the opposition of the trade, they persevered in the use of the new metal until they had conquered all its defects.

Having thus briefly introduced the new metal to the notice of the reader, we will proceed to describe the method of working it up into the small articles which adorn our tables, and serve our uses in so many ways. Let us suppose that the articles to be produced are spoons and forks. The first thing to be done is to cast the alloy into ingots of long flat shape, convenient for rolling, being careful that the three ingredient metals shall be thoroughly mixed, so as to produce a perfectly homogeneous mass. The "strip-caster," as he is termed, is bound to exercise great care in this respect, the whole success of the after operations depending greatly upon his skill and attention. The ingots, or "strips," are then rolled into plates, to a gauge corresponding to the thickest part of the spoons or forks that are to be made. The width of the plate will be equal to the length of those articles. It is then cut across with shears, which slice off little tapering strips in the manner of a nail-cutting machine, taking them from head to heel, and *vice versâ*, so as not to lose a scrap of the material. Being annealed thoroughly, they are next "cross rolled," which means spreading out a portion of the broad end to form the bowl, and a portion of the other end to form the handle of the spoon. Boys place them one by one under the rolls, and for the broad end it will require several rollings before the pieces are sufficiently flattened out. They are now in shape something like miniature malt shovels, and a stranger would suppose that they were made of iron, they being in tint and general appearance exactly like that metal in the forged state. The universal press now comes into operation, and a pair of cutting-out tools give the unshapely articles the perfect outline of a spoon, or fork, as the case may be. In this state they are turned into the "pickle," which, as we have explained in a former article, consists of diluted or weakened aquafortis, and whose office is to cleanse the metal from grease and other impurities, and to remove the "scale," which is the burnt outer surface caused by the several annealings. They will be of a dirty-brown colour when they come out of pickle, and a dip in the strong acid will restore their natural complexion of a dead white. The next process is planishing. German silver becomes hard by beating or rolling, and advantage is taken of this property to procure rigidity where it is wanted, viz., in the stem, by compressing that part between dies of plain surface, till the requisite degree of firmness is obtained. A filer now smoothes the flat of the stem on the under side, and puts in the trade-mark at a press, also smoothing a small portion of the bowl-part for the purpose of the next operation, which is stamping upon it the little projection which in trade *parlance* is called the "heel," and which seems to indicate the juncture of the bowl with the stem. There will also be a little swelling on the other end of the handle, called the "nib," and this is also struck on at this stage. Should the spoon or fork be of an ornamental pattern, such as the "lily," the "wheat-ear," and many others well known to retailers and the public, of course such pattern will have to be stamped on also; the parts being previously well smoothed to admit of a clean impression being made. The "rough-maker" now takes the article in hand, smooths off the burr left by the stamp, strikes up finally the under side, and bends down the little curve at the end of the handle over a block with a small wooden mallet; then strikes up the front of the stem, smoothes the edges, and bevels them. They then leave his hands for a while, and go to the "bowler," who domes up the broad end into the semblance of a bowl, with a press or stamp. Two or three blows will be requisite to make the concave deep enough, according to the size of the spoon: a soup-ladle would require eight or nine blows. The rough-maker now receives them again, strikes off the top edges of the bowls perfectly level, smoothes off all the sharp edges, and "sets" them, *i.e.*, bends them into graceful and uniform shape over a block, so that they may lie nicely in each other. He uses for this purpose mallets made of tin, boxwood, or horn, and compares his work with a model from time to time. When he has done with them, they are, in fact, perfect articles, and only require polishing and plating to fit them for sale.

The description just given would apply equally in the main to the manufacture of forks as to that of spoons; in fact, the same set of workmen would manipulate both, but there are some points on which the processes diverge. After being cut out by the cutting-tools, the next step in the manufacture of a fork would be the piercing—viz., cutting out the spaces between the "tines." The blank is, in the first place, cut a little larger than is necessary in order to leave room for a "get," or solid piece at the end of the prongs, which is retained during many of the subsequent processes for the purpose of maintaining the requisite rigidity to keep the article in shape. Thus, the spaces are not cut out right to the end, but stop short within about a quarter of an inch, the extreme end being left solid as at first. The cutting-out tools are of the usual fashion used in a press, with the exception that the upper tool is shaped longitudinally in the form of a wedge, the apex of which touches the fork-blank first in the middle. It has thus a gradual cutting action, something like that of a pair of scissors, and cuts out the piece rather by continuous pressure than by a sudden blow, thereby avoiding the danger of fracturing the metal. A line of little studs on the bottom die, close by the side of the slit, directs the workman where to place the blank to make the first cut, and for the second he places the slot just made on to the studs, and so on, ensuring equal distances between them. The article is set, filed, and stamped with the "get" still on, and it is cut off the last thing to allow of the prongs being pointed and filed up. A very beautiful method is practised at Elkington's and other manufacturers of best work, of putting solid silver points on the prongs of electro-plated forks. The points, about half an inch long, are neatly dovetailed into the German silver, soldered, dressed off, and plated all over, so that the joint is thereafter undiscoverable, and for all practical purposes the article is the same as a solid silver fork. There is no danger of the joint ever giving way, if well done.

At this stage the work is subjected to a careful examination, to see if any defects have appeared in the metal, and if the workmanship is good and true. A good spoon should be perfectly level on the top of the bowl, the edges even and regular, and the contour graceful and well balanced. If one side of the bowl is sounder or fuller than the other, it is said to have the *toothache*. The stem should be set straight with the bowl, and bent so that half-a-dozen spoons may lie nicely within each other. When all these points have been duly rectified, the articles are given into the hands of the polisher.

The *rationale* of all polishing is simply brightening by abrasion, or scratching of the surface, and the utmost that can be done is to make the scratches as fine as possible. A perfectly smooth surface it is impossible to obtain, as no medium can be employed but will remove something from the substance, and it must do so by attrition. The smoothest wash-leather, if used to rub up metallic surfaces, will become impregnated with the fine particles which it removes, and even the human hand, the best polishing medium known, will take up a very small portion of what it brightens, and waste it to that extent. Probably the brightening effect is due to the presence of the impalpable particles of fine dust which are always floating about in the atmosphere, settling upon everything, being

inhaled with the breath, and entering into the organisation of all things that live. Being parts rubbed off from the solid matter of the earth, this dust is simply grit, as much so as sand or gravel, and under the microscope would present the same characteristics. Therefore, the very highest polished surface is simply a series of scratches, the finer and more numerous they are the greater being the brilliancy attained.

Our spoons and forks, if they are to go forth to the world as German silver wares without disguise, will now receive their final touches, and be disposed of at once; in which case they will be first "bobbed" with fine sand on an ordinary buff-covered polishing wheel, and afterwards finished off with lime and rouge. The finishing bobs are made of a number of loose discs of cloth, placed close together, and threaded on the spindle like an old-fashioned mop on a mop-nail. They revolve at an enormous speed, and when the spoon or other article is pressed by the workman against the soft pad, dressed with grease and fine powder, it receives as high a polish as it is possible to give it. The colour and gloss are brought up afterwards to full perfection by "handing," *i.e.*, brisk rubbing with the palm of the hand.

If they are intended for plating, however, the polishing of the wares stops short at the first process, and they are sent down to be silvered, after having been bobbed with sand. Before entering upon a description of the present chemical method of plating, it will not be improper to advert briefly to the old process, by which the table ware of our grandmothers was honestly coated with a layer of the cleanly and respectable metal. We may premise that the base in those ante-German silver days was frequently iron, and among family relics may often be found a silvered spoon, the thick white coating of which has been eaten through in pin-holes or small streaks by the rust that is corrupting underneath. The method of plating them was in this wise:—The article was first immersed in a solution of zinc with some strong acid, generally smoking salts, which left a strongly adhesive film upon the surface. It was then dipped in a caldron of boiling tin and lead, acquiring a tolerable coating of this material, the surplus of which the workman threw off by vigorously swinging the article in a trough. When cooled, the roughnesses were taken off with a "smooth" or scraper, and it was ready to receive the silver. Holding it with convenient clams in his vice, the workman would lay upon it a piece of thin leaf-silver, cut roughly to the required outline, and would press it down with a hot soldering tool, or "doctor," till the tin underneath was melted, and the silver adhered. He would then serve the other side in similar fashion, pressing as much as he could conveniently all the interstices of the work, and making as good a joint as possible on the edge, where he would turn down the edges of the silver after trimming it off with a glazier's knife. This done, he would sprinkle resin over the surface, and turning to the hearth, would hold the article in the fire till the resin blazed, by which token he knew that there had been heat enough to run the solder. He had to be wary about exceeding this heat by even the slightest degree, or otherwise the thin silver would also melt, and run away into the fire. Then, while the work was still hot, he hasted to the bench, and rubbed down the plating with a handful of tow, working it well into all the hollows; after which treatment there was no fear of its coming off, nor could any indication be perceived that it was simply a veneered, and not a solid article. Even now, many articles of table ware are plated in this fashion, especially steel articles that are exposed to wear. Thus, the blade of a plated dessert-knife must be of steel, because German silver would not possess the requisite degree of rigidity and elasticity; if plated by the electro process, the plating would not be sound enough for wear, on account of the weak chemical affinity between the two metals; but the old process produces a good, sound, wearable article. The new method is by far the most beautiful, and the most suitable for general work, besides being the most scientifically interesting.

Electro-plating.—It will not be out of place, however, briefly to recount the points of interest in the development of this latest addition to our productive agencies. The discovery of Galvani that electricity could be evolved from substances by other means than friction—in fact, by simply placing two metals together—was undoubtedly the first step in the series of events which led to its birth. He supposed that the effect was due to simple contact, and that the subtle fluid was always being given out, though in quantities imperceptible to the senses, whenever two substances touched. Volta, who followed him, seemed to prove by his experiments that it was rather the result of a chemical action, the rushing together of particles having an affinity for each other into chemical combination, electricity being disengaged in the process. Thus, the air itself, charged with a powerful dissolvent, oxygen, ever tending to oxidise or rust any metal exposed to it, is continually producing electricity by forcing the particles of metal to combine with its own particles of oxygen. When two metals are brought into contact which have different degrees of affinity for oxygen, the violence of the oxidising action in the one and the weakness of it in the other will cause a current of electricity to set in between them, and by this means only does its presence become visible. The action of the air, however, at the best is only slow, and it requires a more powerful dissolvent to produce a current of electricity of any considerable force. Water will do better, but the best medium is some corrosive liquid that will disintegrate the particles of metal with great rapidity. Volta, therefore, instead of placing his metals one upon another, inserted between them a piece of cloth saturated with an acid, and connected the two metals with a bent wire touching both, such connection being necessary in order to induce the currents. The acid acting strongly upon the bottom plate, which was of zinc, and feebly upon the upper plate, which was of copper, caused a continual flow of electricity from the one to the other. He increased this by building up a series of plates, with saturated cloth between them, in proper order, and fixing the conducting wire to the top and bottom plates only, thus getting the accumulated electricity into one current; and this apparatus was known as the *voltaic pile*. It was soon perceived that as the only use of the cloth was to retain the liquid, the metals had better be immersed in it at once, and so came the construction of the trough battery which is now universally used. A pair of plates is suspended in the corrosive solution apart from each other, but connected with copper wires or bands at the upper edges; and intensity to any extent is produced by multiplying the number of troughs or cells, and establishing a connection between them. Sir Humphry Davy used a battery consisting of 2,000 cells, and with it he decomposed alkalies and earths that had hitherto defied the power of chemistry.

The difference between the electricity generated by the voltaic battery and that evolved by friction is that the former is much greater in *quantity*, and is also continuous; owing to this, it is capable of producing effects that are beyond the power of instantaneous electricity, not the least of which is that of decomposing compounds. During the progress of the many experiments that were made to ascertain the best form of battery, and the best liquids to use, the invention of Daniell's Constant Battery took place. It has been explained that success depends upon the violent action of the acid upon one plate and its feeble action on the other. Daniell's battery consisted of an interior cell of unglazed porcelain, placed in a larger cell of copper. The inner cell was filled with dilute sulphuric acid, and the outer one with a saturated solution of sulphate of copper. A rod of zinc was suspended in the acid, which acted strongly upon it, while the sulphate acted mildly upon the copper, the electrical influence passing, where the corrosive liquid could not, through the pores of the inner jar. Thus the necessary conditions were simply obtained. It was found, however, that by an indirect action, which we need not stop to explain, the electric current was setting free the particles of copper from the compound, and depositing them upon the metallic cylinder itself. Here was the first indication of electro-deposition. There was no thought at the time of turning the discovery to account, and the only thing done was to provide, by very simple means, for renewing the waste in the sulphate. For a detailed description of this process we refer our readers to a paper on "Voltaic Electricity" in THE POPULAR EDUCATOR, Vol. VI., page 8.

FARMING AND FARMING ECONOMY.

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XXII.—FARM BUILDINGS.

THERE are many kinds of farms differing in character from each other in the quality of their soils, the proportion of arable land to pasture, and in physical position.

1. *Pastoral Farms*, devoted to the breeding and rearing of

young animals. Sheep usually occupy the poorer and more exposed soils adapted to this purpose, while cattle are found upon the lower and richer lands. Such farms are usually very extensive, and occasionally occupy many thousand acres, and extend over several square miles. Such farms do not require buildings of a complex or expensive character, and where sheep alone are kept, mere "stells" are sufficient. These stells are of various forms, and consist of walls destitute of roofing, and so arranged as to protect the sheep from severe blasts of wind, and during storms of hail or sleet. In selecting a site for a stell a sheltered situation is desirable, and the simplest forms are circular, the circumference being broken in one or two places for the admission of the sheep. A stack of hay, securely railed off, often occupies the centre of this enclosure, and the insides of the wall may be fitted up with racks for supplying hay in stormy weather. Two parallel walls, with a third wall connecting them at their centres, and at right angles to their direction, is a useful form of stell. These primitive farm-buildings, if so they may be termed, can, by a small additional outlay, be rendered both more efficient and sightly. Thus, a double wall, with a plantation between the two walls, is an admirable plan, the shelter in such stells being very perfect. The diameter of the internal circle will be about 18 yards, but varies according to the flock. A still more complicated form, and one calculated to give shelter from every wind, is of the form shown in Fig. 1. The centre is planted, and the walls are so arranged that four capacious bays give shelter to the sheep.

Carse Farms are situated in low, flat, clay districts, as in the Carse of Gowrie, in Perthshire. The retentive nature of the land adapts such farms for corn rather than live stock. The buildings are therefore limited to the accommodation of the crops and the means of preparing them for market, together with yards for a few "straw beasts" and milch cows.

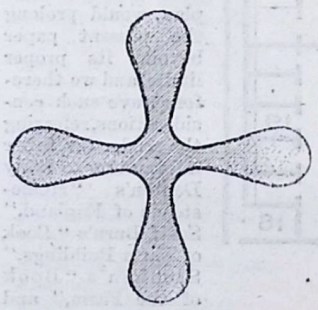

Fig. 1.

Dairy Farms occur in districts where good pastures abound; and buildings suitable for the manufacture of butter and cheese, together with accommodation for a large stock of cows, form the principal and most characteristic features.

Suburban Farms are usually cropped with a view to supplying the neighbouring town with various kinds of vegetable produce and milk. Straw also commands a high price: we shall therefore find the buildings specially adapted to cow-keeping, while the most economical use of straw is obtained by the construction of liquid manure tanks. In other respects the buildings may resemble those on the farms next to be considered.

Mixed Husbandry Farms.—On these the most complex arrangement of buildings is required, and we shall therefore consider the rules that should guide us in the selection of the site and the designing of such farm-buildings.

Farm-buildings for mixed husbandry farms are needed for four important objects: 1st, for the comfort of live stock; 2nd, for the preservation and accumulation of manure; 3rd, for the preparation and storing of grain; and 4th, for the stores of cake, artificial manures, wool, and other substances required on farms.

With regard to the position or site of farm-buildings, we must consider the size of the farm; the relative position and proportion between arable and pasture land; the form of the farm; shelter; the inclination of the ground; the water-supply; and the proximity of good roads. As a general principle, the nearer we can have the homestead in the centre of the farm the better, always deviating according to the predominance of arable land, where, of course, the bulk of the work is conducted. On very large farms it is a question whether the homestead should consist of one central set of buildings or be divided into two or more smaller sets, placed conveniently for the surrounding land. A good rule is, never, if possible, to be obliged to cart the produce of fields, or manure, further than one mile. When this distance is exceeded it is much the best plan to adopt the system of field-barns and straw-yards, so as to diminish the cost of carting. There are advantages in a single and central homestead. The whole is under the eye of a master; machinery and power is concentrated; labour can be more comfortably and economically carried out; and a greater amount of comfort and warmth is obtained for the stock. The introduction of portable threshing machines has done much for the scattered buildings plan, and on large farms this system has also its advantages. In harvest, for instance, it is a great comfort to stack the corn in the fields, and, unless the farm is provided with a rick-yard of special merits, there is little doubt the corn comes into condition sooner in the open field. If, then, we build stacks in the field, it will be as well to thresh them there; to tread down the straw by means of cattle in yards at the same place; to cart the turnips grown in the land adjoining; or to provide other foods, and make manure near the place where it will be wanted. This is excellent management upon large and straggling farms; but on compact and smaller farms a central homestead is to be preferred.

These preparatory considerations having been settled, we proceed to enumerate some of those principles which should be kept in view in constructing our plan. The cost must be restricted within reasonable limits. The character of the farm and the kind and quantity of stock it is best fitted for are important considerations. The economy of labour and the comfort of the animals which have to occupy the buildings must also be consulted. The central position of the homestead may be deviated from in order to obtain a good supply of water for drinking purposes, or as a power. Where the water-supply is deficient, much may be done by collecting the water from the roofs in reservoirs.

The general form of farm-buildings should be rectangular. They usually consist of some three or four parallel ranges of roofed buildings, devoted to different purposes, and extending from north to south, so that both sides may receive an equal share of sunlight, and all may be protected from the east and west winds. The north ends of these parallel ranges join some important offices, which, passing from east to west, give the rectangular outline already insisted upon. The scale should be liberal and roomy, so as to ensure plenty of space for straw and roots; and the method of transit from one part to another should be carefully studied. The principle of internal arrangement is as follows:—The straw is the most bulky and most frequently required material in the homestead. The source of straw, therefore, or threshing machine, should occupy a central position, and the buildings for the accommodation of live stock should be arranged at a greater or less distance from the straw-barn, according to the quantity of straw the animals require.

The rick-yard should occupy the extreme north of the homestead, and if there is a gentle slope towards the barn, so much the better. There are two good reasons for placing the rick-yard in this position: first, it gives shelter from the north wind to the remainder of the buildings; and secondly, it is better for the corn, as in this exposed situation it comes sooner into "condition." In a line due south from the rick-yard, and occupying a central position with regard to the other buildings, we should find the barn containing the threshing machine; and continuing the line southward, past the machine, we ought to find ourselves in the straw-barn. On either side of, and parallel with, this main building are straw-yards and sheds for live stock, arranged with a view to straw supply; and other offices, such as implement and cart sheds, root-houses, and store-rooms, are placed in the most convenient situations. The corn-barn containing the machine is usually a two-storeyed building, and the granaries should extend as two wings eastward and westward from it. Thus we have established the position of the central barn, and the granaries running across at right angles to it will form a good screen from the north wind.

The following plan (Fig. 2) is adopted on an estate known to us, and the principles which have been observed in these excellent buildings are fairly illustrative of what has been advanced in these columns.

The *Barn* is usually a long rectangular building, one part of which is floored, and contains the threshing machine, while the remainder is open to the top. The first portion forms the upper and lower corn barns, and is situated next the rick-yard, while the open portion is known as the straw-barn. In the homestead of the Flemish Farm, Windsor, made to accommodate the stock and crop of 190 acres arable and 200 acres pasture land, the inside measurements were as follow:—

Upper barn . . .	23 × 23 feet.
Corn (lower) barn . .	23 × 23 ,,
Straw barn . . .	49 × 23 ,,

At Thorney Farm, Cambridge, the barn accommodation for 400 acres arable land and 100 acres pasture are—

Upper barn . . .	21 × 44 feet.
Lower (corn) barn . . .	21 × 44 ,,
Straw barn . . .	21 × 49 ,,
Additional threshing room	20 × 23 ,,

Cattle Accommodation: Folds, Boxes, and Byres (stalls).—All three forms of accommodation are ordinarily used. Small folds are an excellent home for store and fatting cattle, but should be provided with plenty of shed-room, and with troughing to carry off the water from the roofs. At the Coleshill Farm, in Berkshire, the property of the Earl of Radnor, a shed runs the entire length, and provides shelter for four yards. The shed is divided into lengths of 17 feet each, and in front of each section is a yard 23 × 17 feet. Water is provided for each court, and feeding-troughs extend along the shed.

Boxes are suitable for fatting, rather than store cattle. They may be built as a double range, with a passage between, and under one roof. Suitable dimensions for each box will be 9 × 10 feet, and the bottom of each must be sunk about 2 feet below the surface of the ground. The boxes will be separated from each other by slip-rails.

The best arrangement for *byres* or *stalls* is a double row, the cows standing head to head, with a feeding passage between. A shed so fitted, 45 feet long and 32 feet wide, exclusive of the thickness of the walls, would provide accommodation for twenty cows. Each cow would have a "standing" of 4 feet 6 inches by 9 feet, with a passage behind her of 4 feet, and 6 feet for trough-room and feeding-passage in front.

Mr. Ewart thus writes upon *work-horse* stables. They should be well lighted, perfectly dry both above and below, have the means of preserving cleanliness at all times, and have perfect ventilation and means to regulate the temperature without subjecting the animals to direct draught. The proper length for a stable will be found by allowing 6 feet for every horse, and the width should not be less than 14 feet. Mr. Scott Burn, however, would in no case allow the width of the stable to be less than 18 feet.

The *calf-house* should communicate with the cow-house, and should be a roomy, well-ventilated building, divided into separate sparred cribs or hutches, each of which should be furnished with a trough and rack. The dimensions of these cribs will vary from 4 × 4 feet to 4 × 6 feet, or even 4 × 8 feet. Glass tiles, loop-holes, and half-doors should be all used in order to ensure a supply of light and air to the young animals.

The *granary* will vary in size with the area of the farm. Taking 20 feet as a constant and convenient width, 60 or 70 feet in length would give ample granary room for even a large farm.

To give any account of the remaining and less important offices already named in the list, and shown in the plan, would prolong the present paper beyond its proper limits, and we therefore leave such considerations, referring the reader for fuller information to Baily Denton's "Homesteads of England," Scott Burn's "Book of Farm Buildings," Stephen's "Book of the Farm," and Ewart's excellent little book, "The Agriculturist's Assistant." We conclude these remarks with the following approximate estimate as to the cost of buildings on farms of various sizes, supplied by Mr. Baily Denton:—

"Farms of 1,000 acres and upwards, of tillage and mixed husbandry, will require an outlay in house and homestead of £4,000 to £5,000.

"Farms of 500 to 1,000 acres, of tillage and mixed husbandry, will require an outlay, as above, of from £2,500 to £4,000.

"Farms of 200 to 500 acres will require, under similar conditions, an outlay of from £1,500 to £3,000.

In the most recent edition of Bayldon's "Rents and Tillages," a farm of 250 acres is supposed to require an outlay in house and buildings of £1,500. Such estimates will, we fear, be rendered scarcely applicable at the present time, on account of the unsettled state of the labour market generally, and of the building trade in particular.

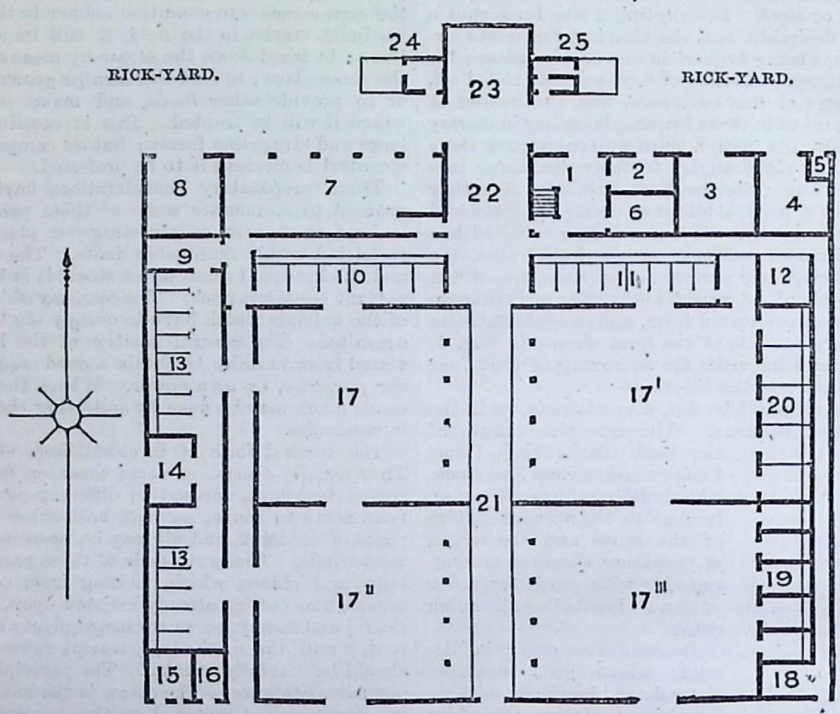

Fig. 2.—PLAN OF FARM-BUILDINGS.

1. Food-mixing room
2. Root-house
3. Engine-room and shop
4. Manure-shed
5. Privy
6. Boiler-house
} With granary overhead.
7. Cart-shed
8. Implement-shed
} With granary overhead.
9. Corn-room.
10. Fatting-stalls.
11. Cow-stalls.
12. Calf-house.
13. Work-horse stable.
14. Harness-room.
15 and 16. Loose boxes for stallion or foaling mare.
17, 17', 17'', 17''', fold-yards.
18. Loose-house, or turnip-house.
19. Pig-sties, with covered feeding-passage.
20. Boxes for cattle, with covered feeding-passage.
21. Sheds for cattle, with straw-barn overhead.
22. Threshing and dressing-floor.
23. Sheaf-barn.
24. Bull-house and yard.
25. Boar-house and yard.

THE END.

CASSELL, PETTER, & GALPIN, BELLE SAUVAGE WORKS, LUDGATE HILL, LONDON, E.C.

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